Institute of Paper Science and Technology
Atlanta, Georgia

SLIDE MATERIAL

To The

PAPER PHYSICS

PROJECT ADVISORY COMMITTEE

March 23, 1994

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

SLIDE MATERIAL

PAPER PHYSICS

March 23, 1994

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

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Rev. 10/90

ON-LINE MEASUREMENT OF PAPER PROPERTIES

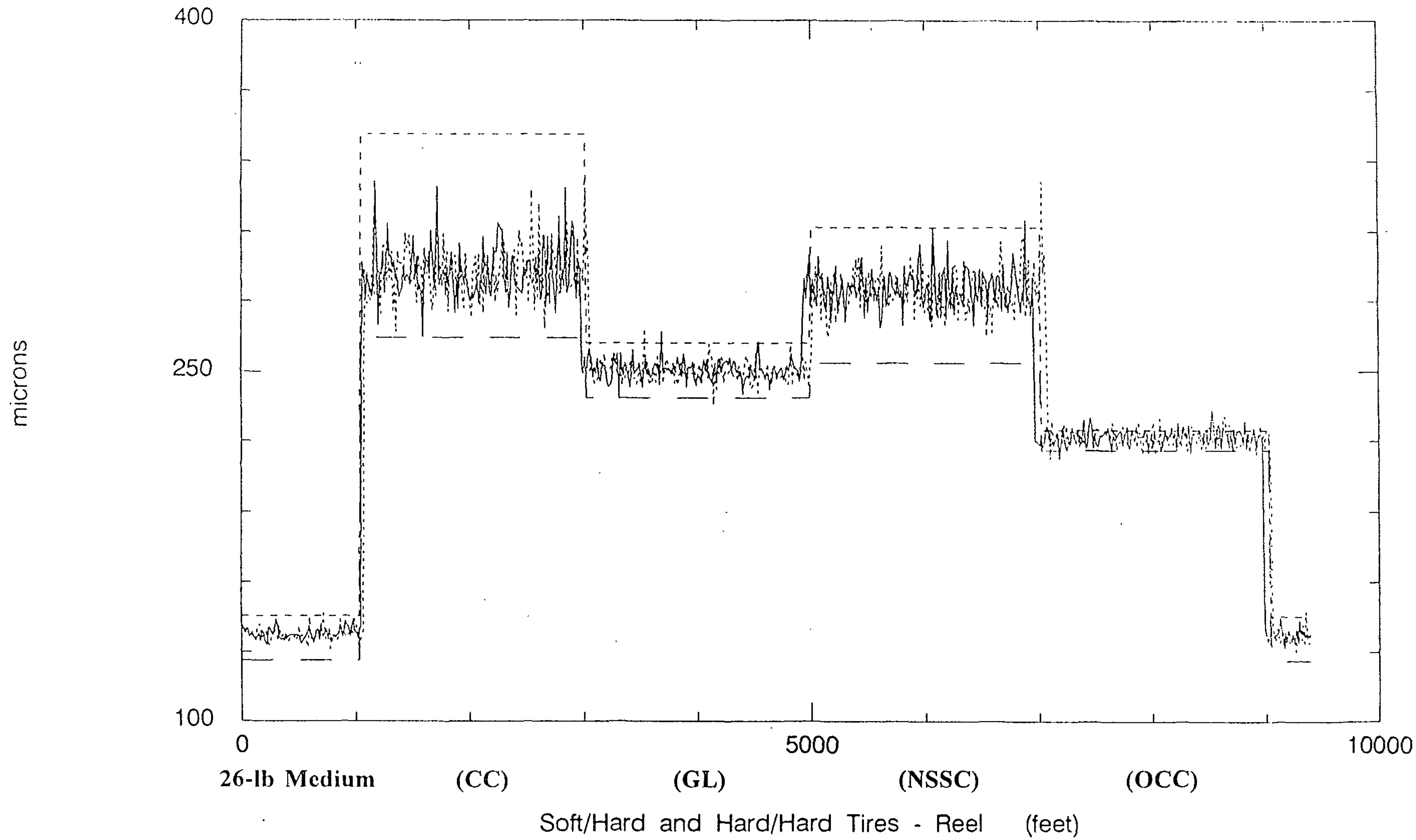
SLIDE MATERIAL

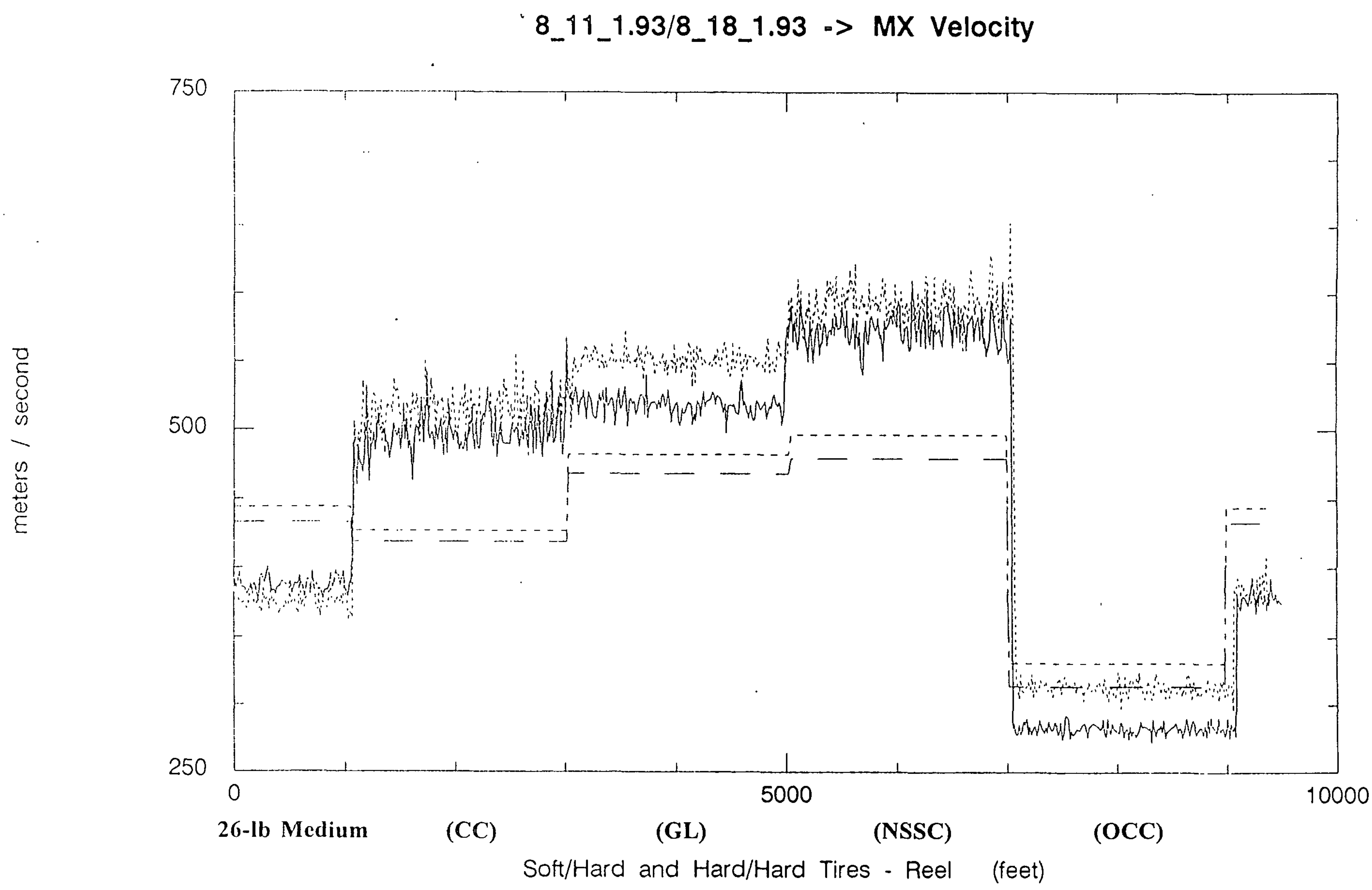
FOR

PROJECT 3332/3869

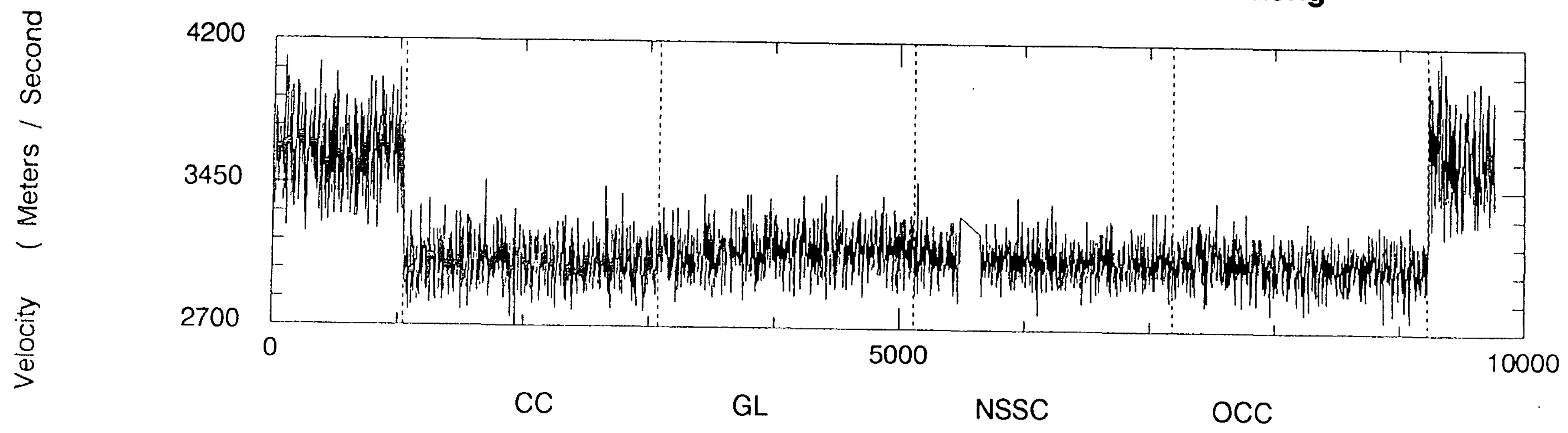
March 23, 1994
Institute of Paper Science and Technology
Atlanta, Georgia

8_11_1.93/8_18_1.93 -> MX Caliper

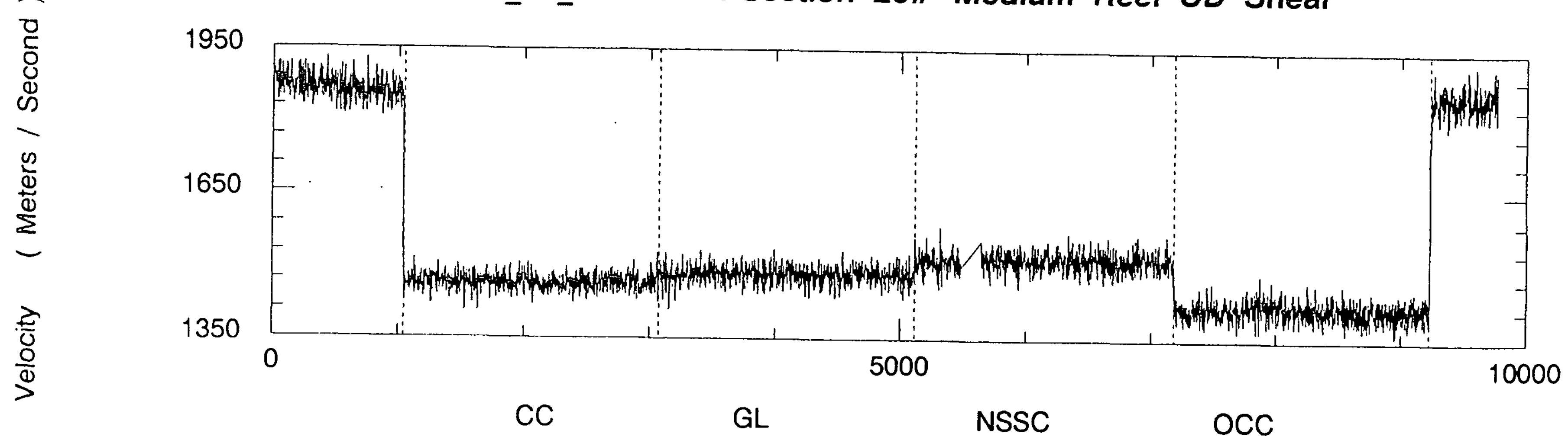



8_11_1.93/8_18_1.93 -> MX Velocity
750
500
250
meters / second
0
5000
10000
26-lb Medium
(CC)
(GL)
(NSSC)
(OCC)
Soft/Hard and Hard/Hard Tires - Reel (feet)

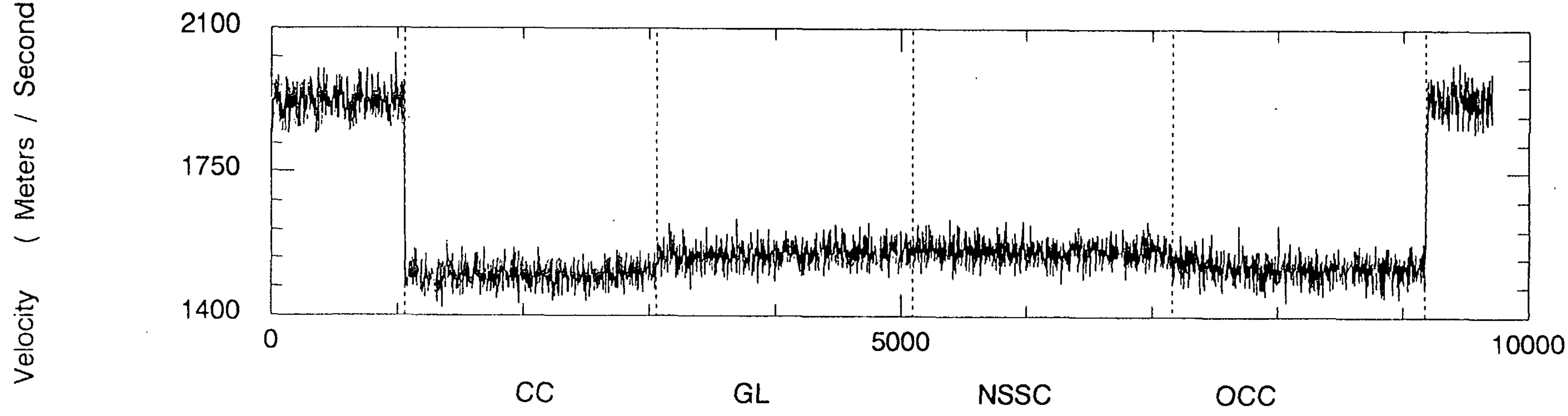
11_10_1.93 -> 4-Section 26# Medium Reel MD Long



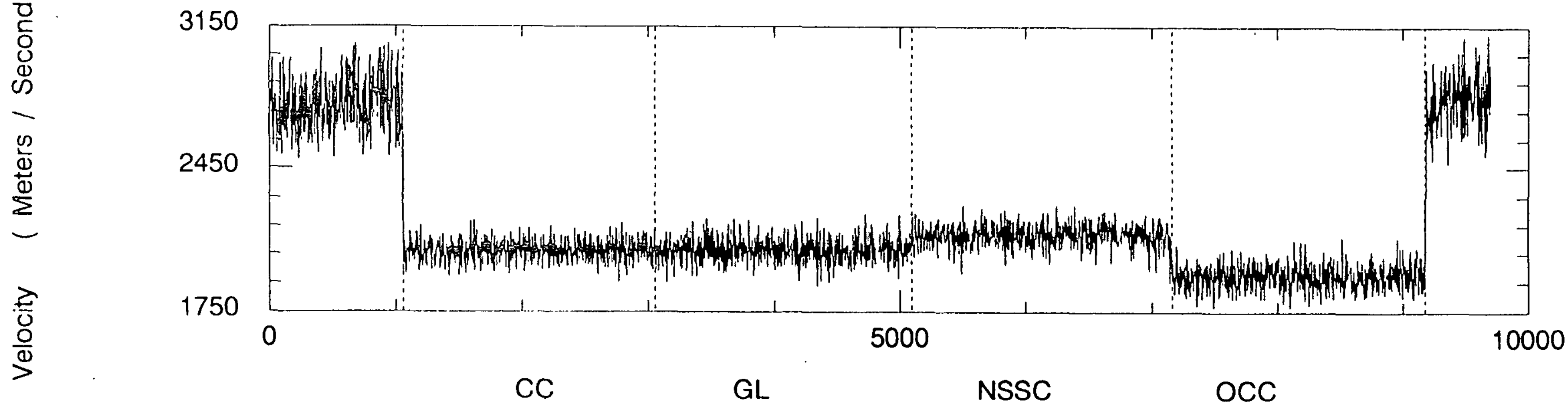
11_10_1.93 -> 4-Section 26# Medium Reel CD Shear

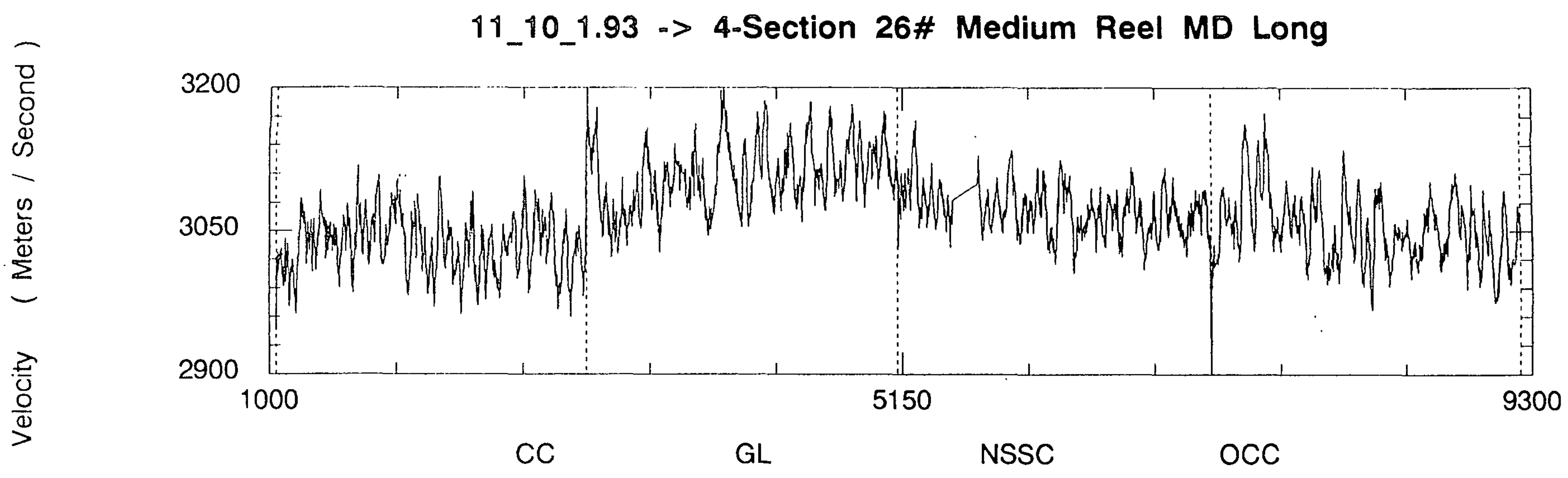


11_11_1.93 -> 4-Section 26# Medium Reel MD Shear

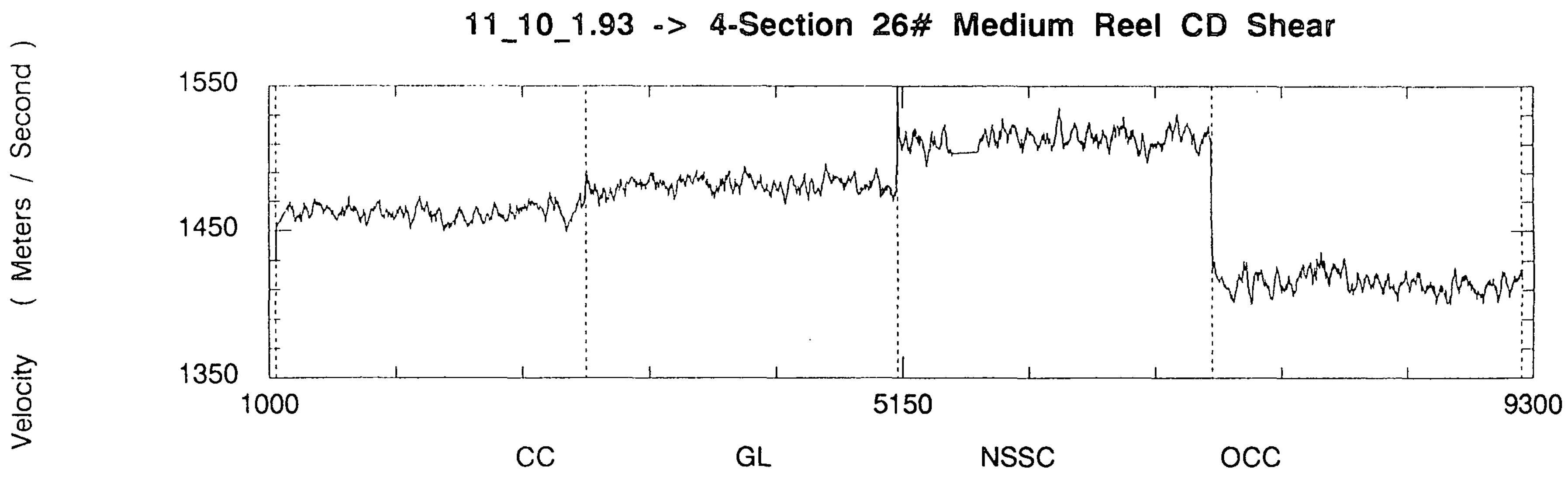


11_11_1.93 -> 4-Section 26# Medium Reel CD Long



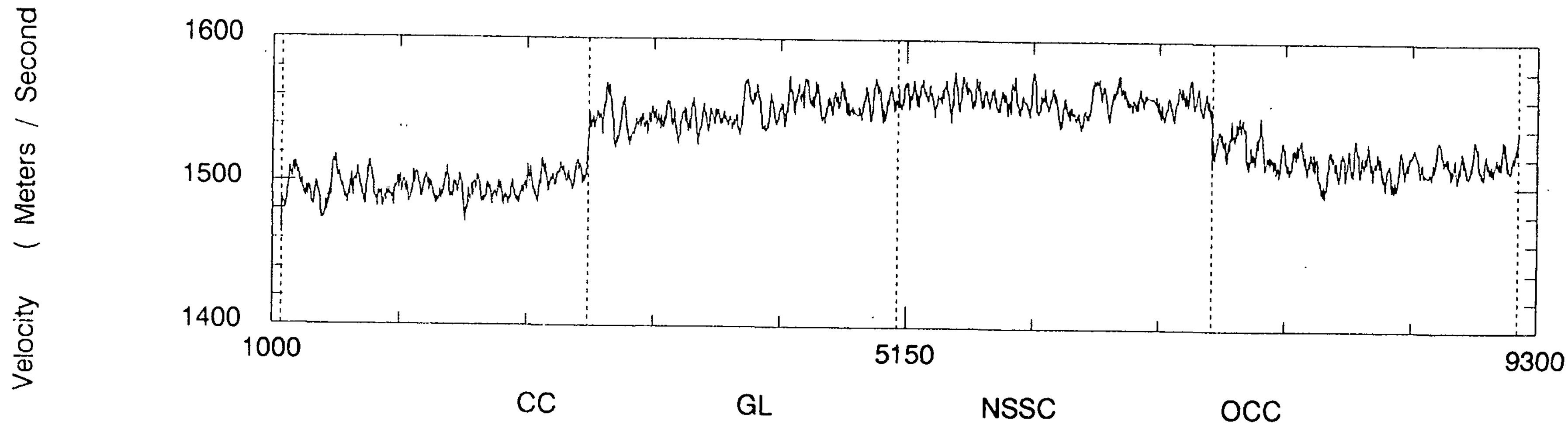


11_10_1.93 -> 4-Section 26# Medium Reel MD Long
Velocity (Meters / Second)
3200
3050
2900
1000
5150
9300
CC
GL
NSSC
OCC

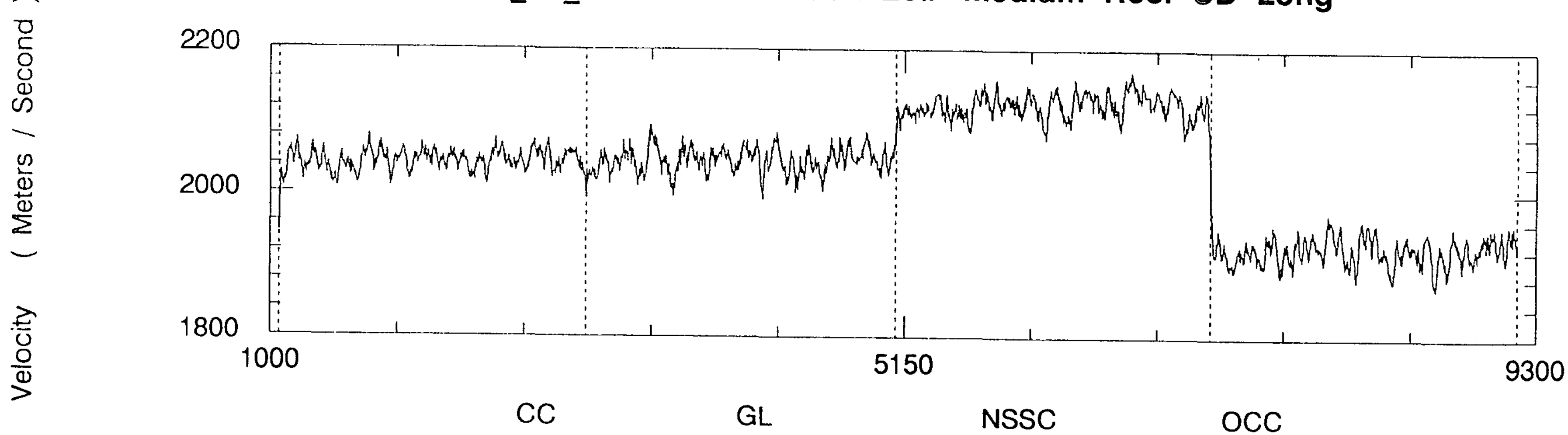


11_10_1.93 -> 4-Section 26# Medium Reel CD Shear
Velocity (Meters / Second)
1550
1450
1350
1000
5150
9300
CC
GL
NSSC
OCC

11_11_1.93 -> 4-Section 26# Medium Reel MD Shear

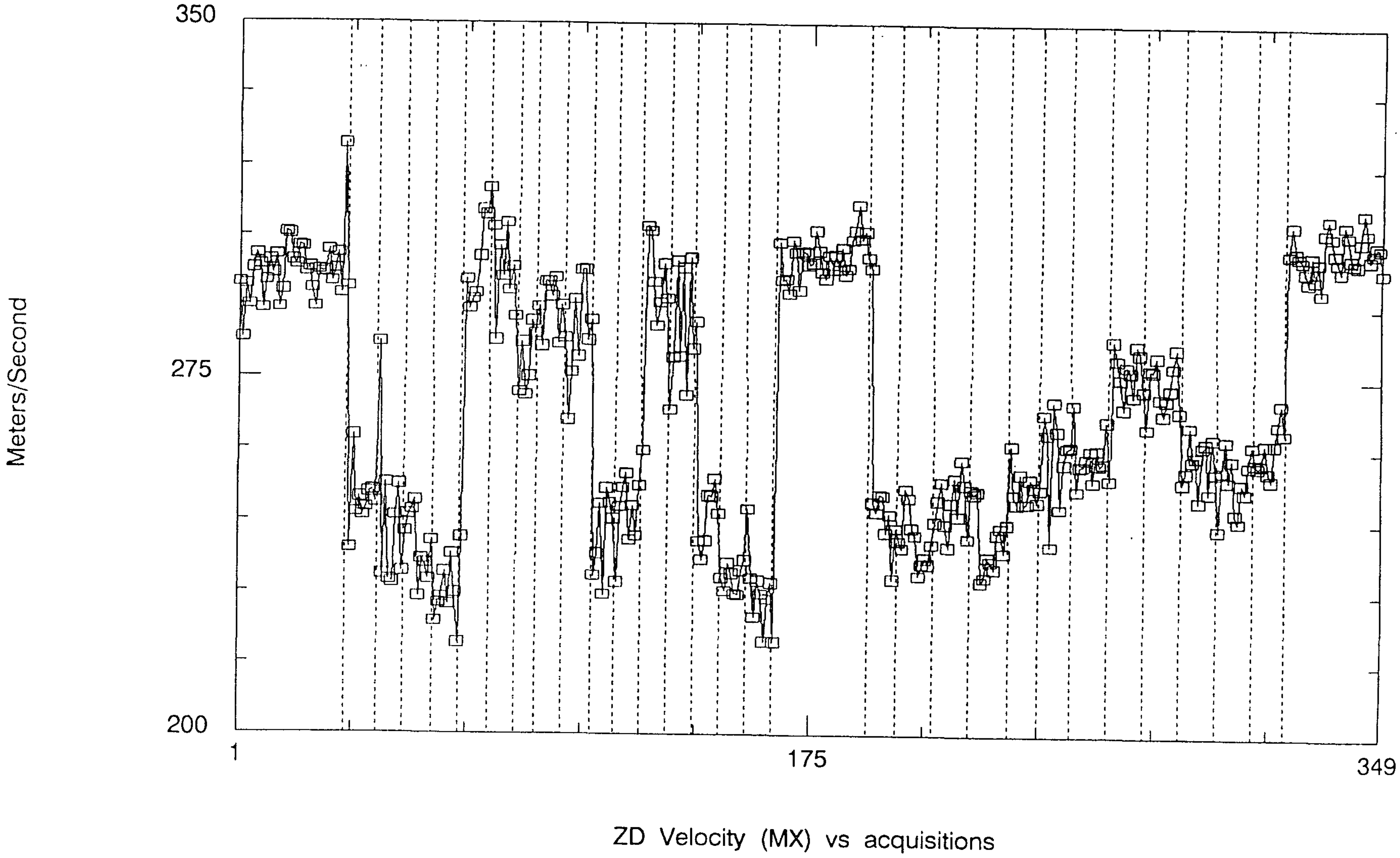


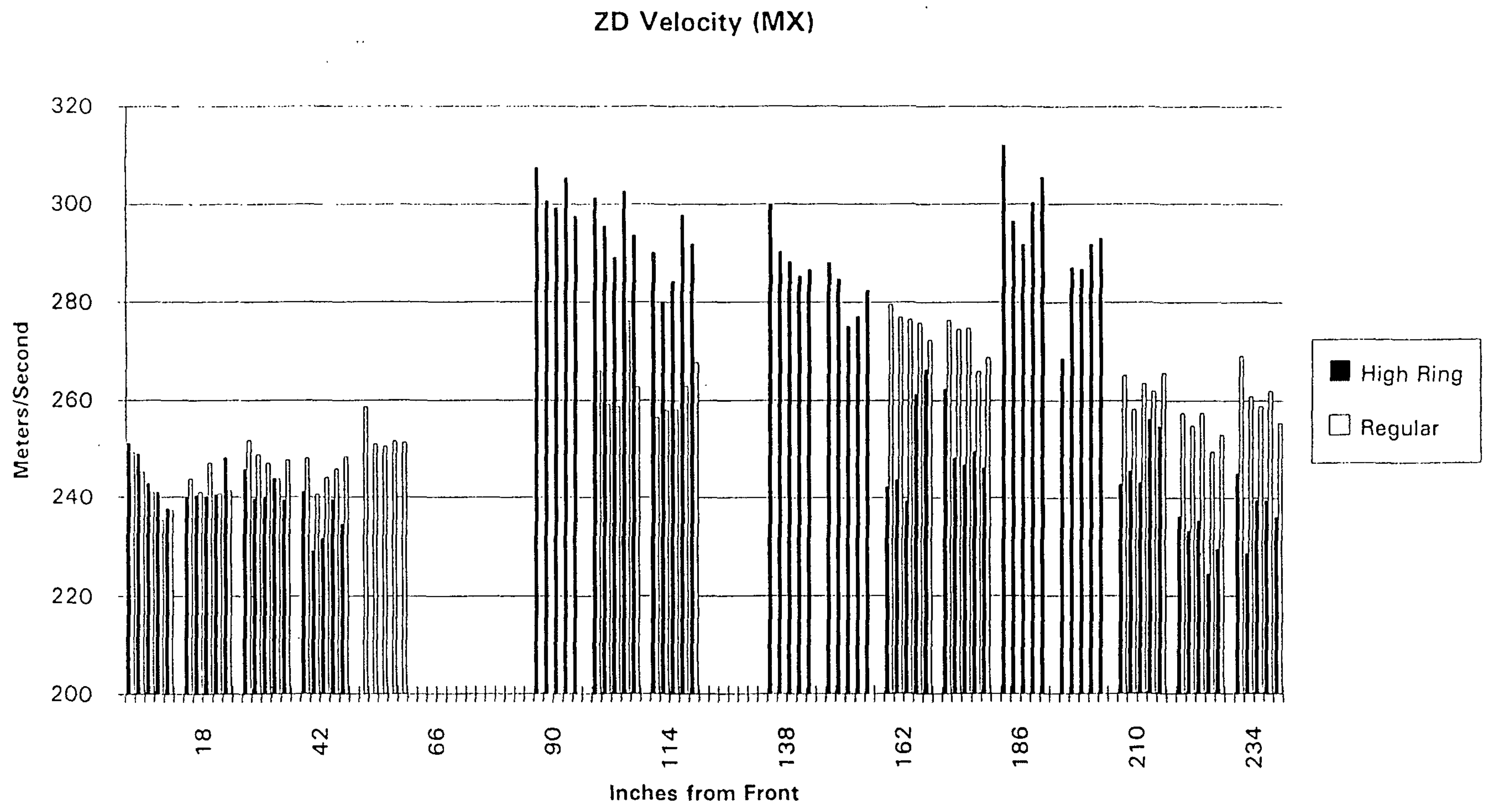
11_11_1.93 -> 4-Section 26# Medium Reel CD Long



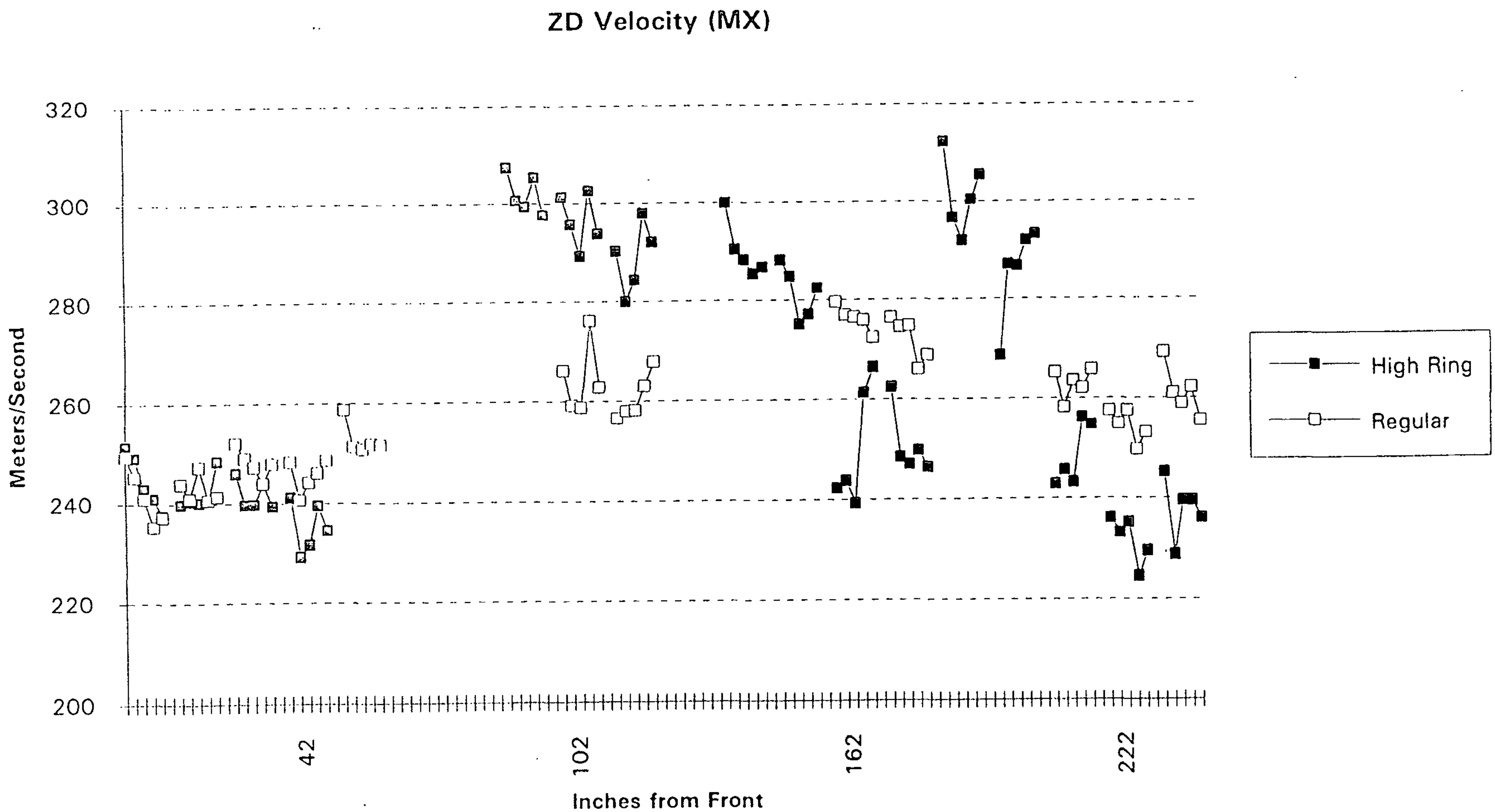
	MD Longitudinal			*CD Shear*					
	Mean	*Std.*	*Var.*	*Mean*	*Std.*	*Var.*			
CC	3036.06	110.3540	0.0363	1462.28	15.9910	0.0109			
GL	3108.51	106.8150	0.0344	1481.40	18.0570	0.0122			
NSSC	3072.59	92.2960	0.0300	1514.39	19.7210	0.1300			
OCC	3053.74	95.2890	0.0312	1415.29	18.8650	0.0133			
	MD Shear			*CD Longitudinal*					
	Mean	*Std.*	*Var.*	*Mean*	*Std.*	*Var.*			
CC	1496.41	25.0136	0.0167	2042.70	49.1780	0.0241			
GL	1550.14	27.2685	0.0176	2045.43	55.8040	0.0273			
NSSC	1559.50	26.1739	0.0168	2123.97	52.6776	0.0248			
OCC	1519.06	28.5115	0.0188	1923.56	55.5876	0.0289			
	VmdVcd/Vsh_md^2			*VmdVcd/Vsh_cd^2*			*VmdVcd/Vsh_av^2*		
CC	2.77			2.9004			2.8338		
GL	2.65			2.8973			2.7674		
NSSC	2.68			2.8456			2.7627		
OCC	2.55			2.9326			2.7288		
Inplane 4-Section Medium Reel taken 11_10.93 and 11_11.93									

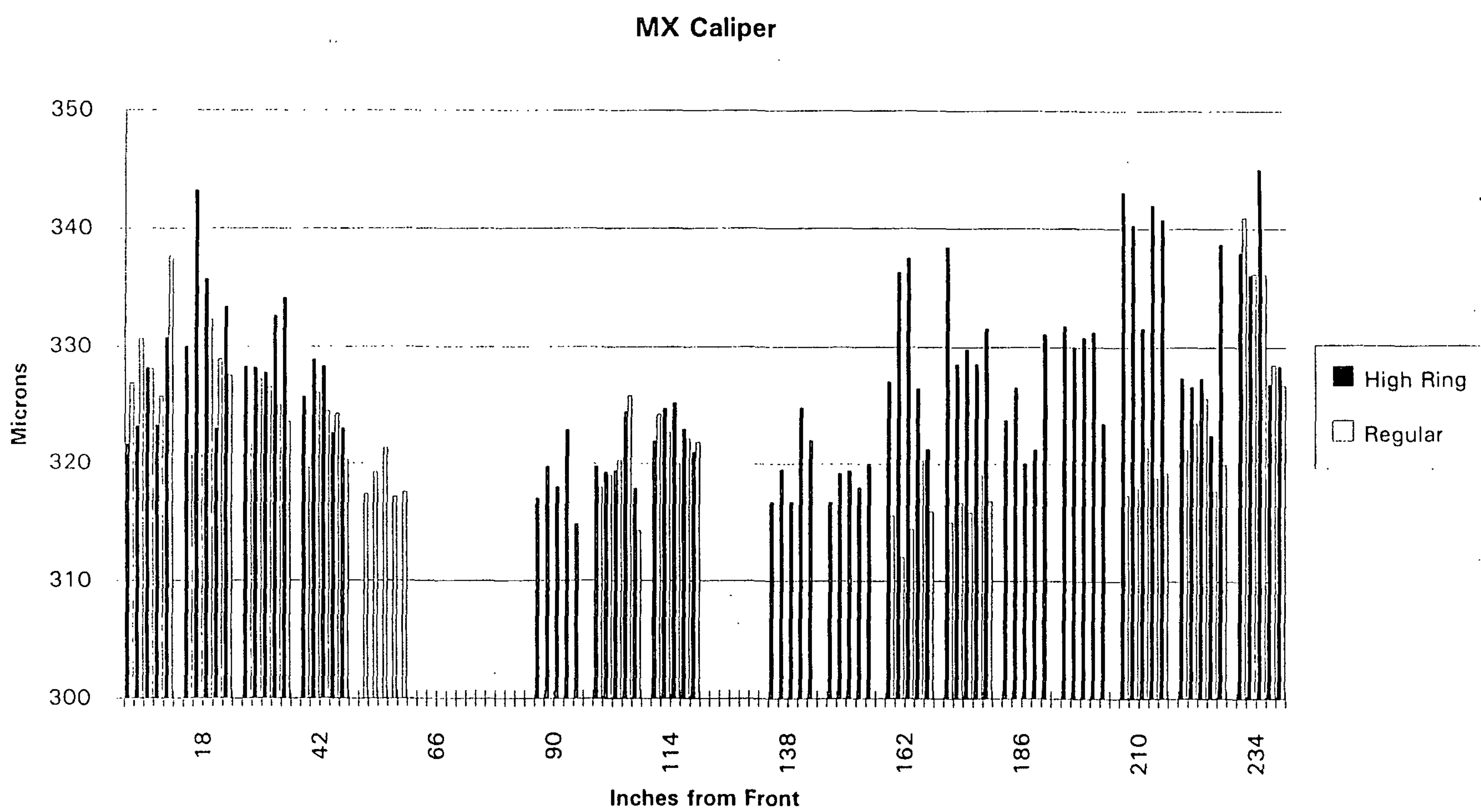
1_25_1.94 -> Position 7, 42-lb liner, HR & Reg



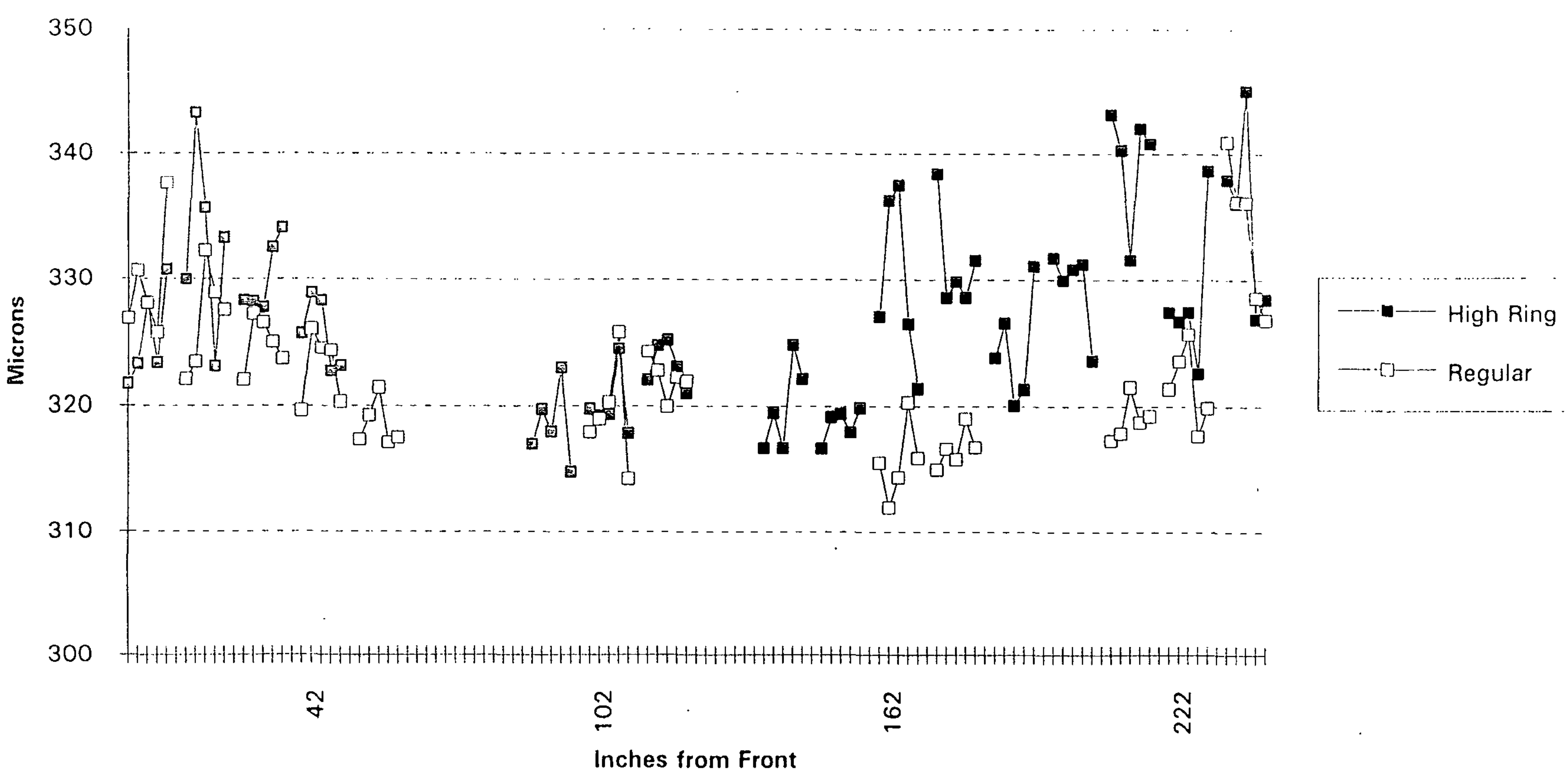


ZD Velocity (MX)
Meters/Second
320
300
280
260
240
220
200
18
42
66
90
114
138
162
186
210
234
Inches from Front
High Ring
Regular


ZD Velocity (MX)
320
300
280
260
240
220
200
Meters/Second
42
102
162
222
Inches from Front
High Ring
Regular

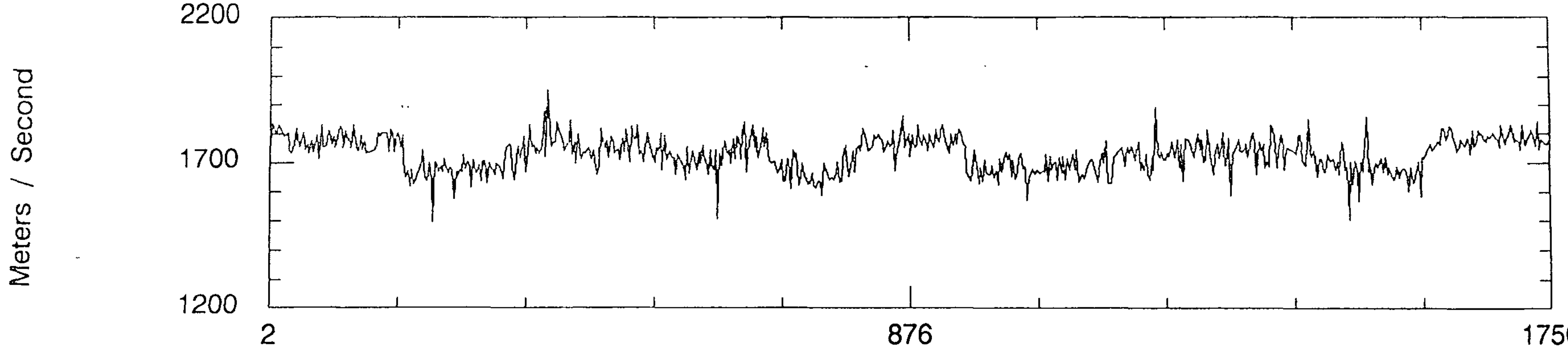

MX Caliper
Microns
350
340
330
320
310
300
18
42
66
90
114
138
162
186
210
234
Inches from Front
High Ring
Regular

MX Caliper



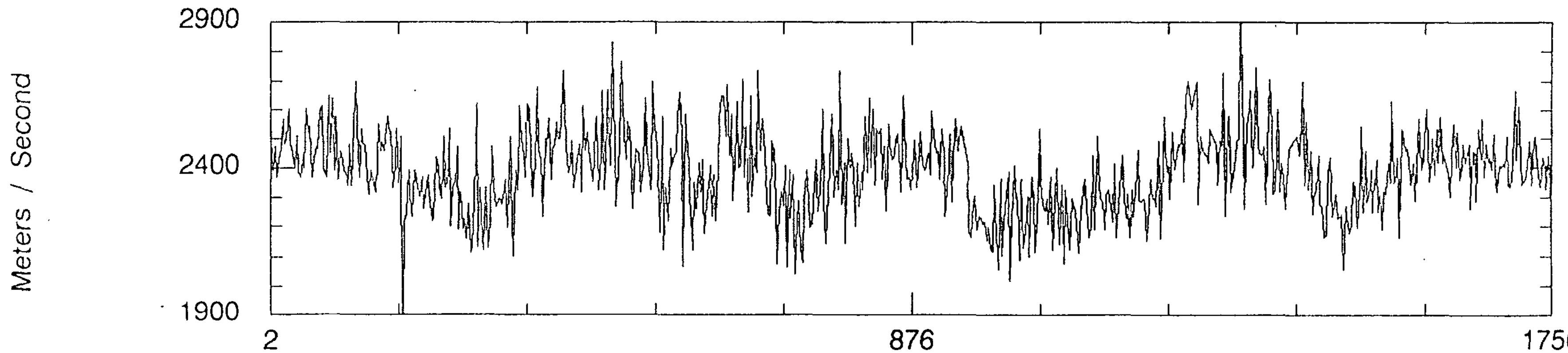
Microns
350
340
330
320
310
300
42
102
162
222
Inches from Front
High Ring
Regular

2_17_2.94 -> 42-lb liner, High Ring & Reg



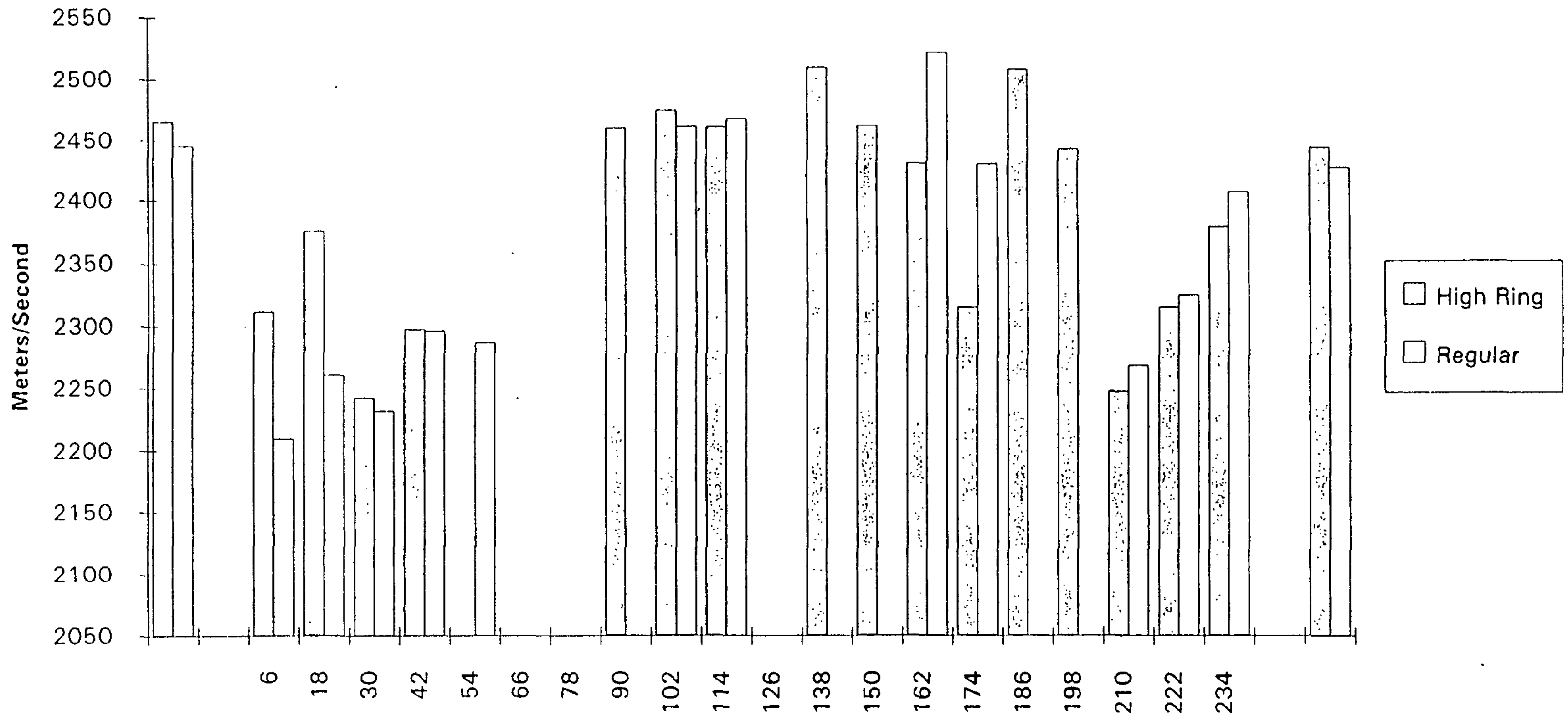
MD Shear Velocity vs Feet

2_17_2.94 -> 42-lb liner, High Ring & Reg

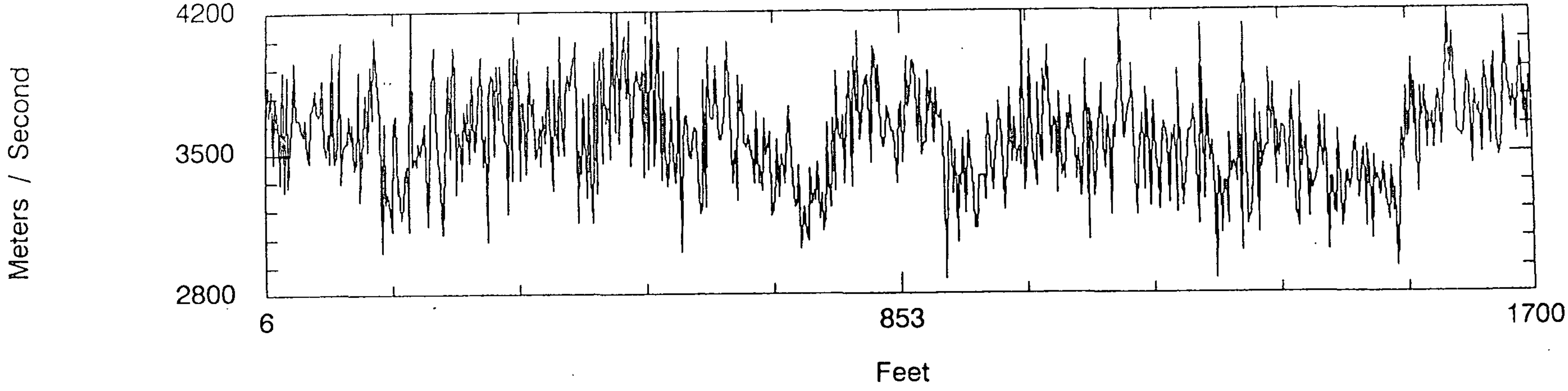


CD Longitudinal Velocity vs Feet

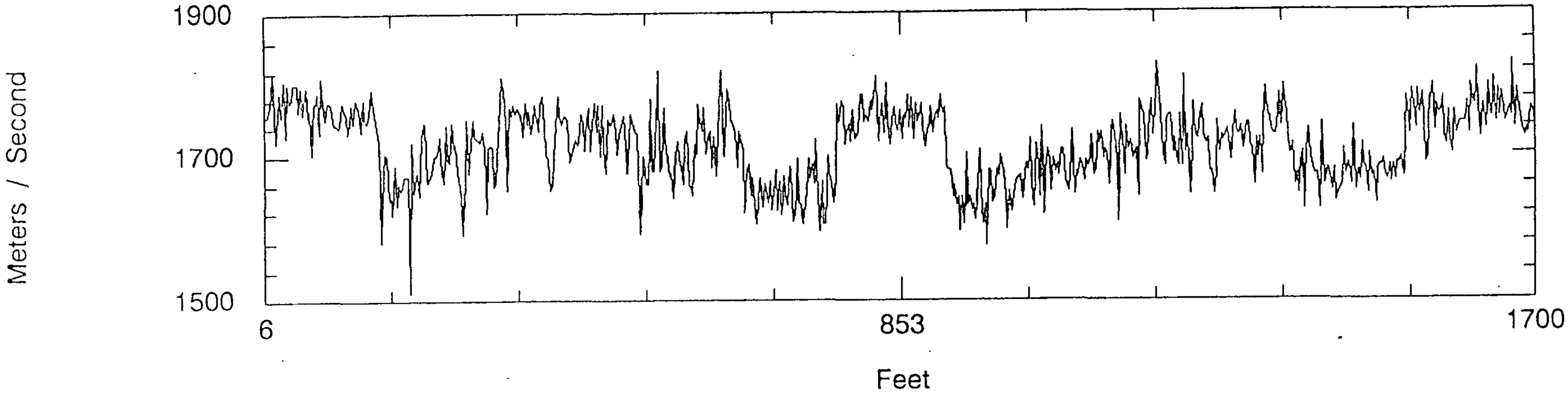
2_17_2.94 -> CD Longitudinal Velocity



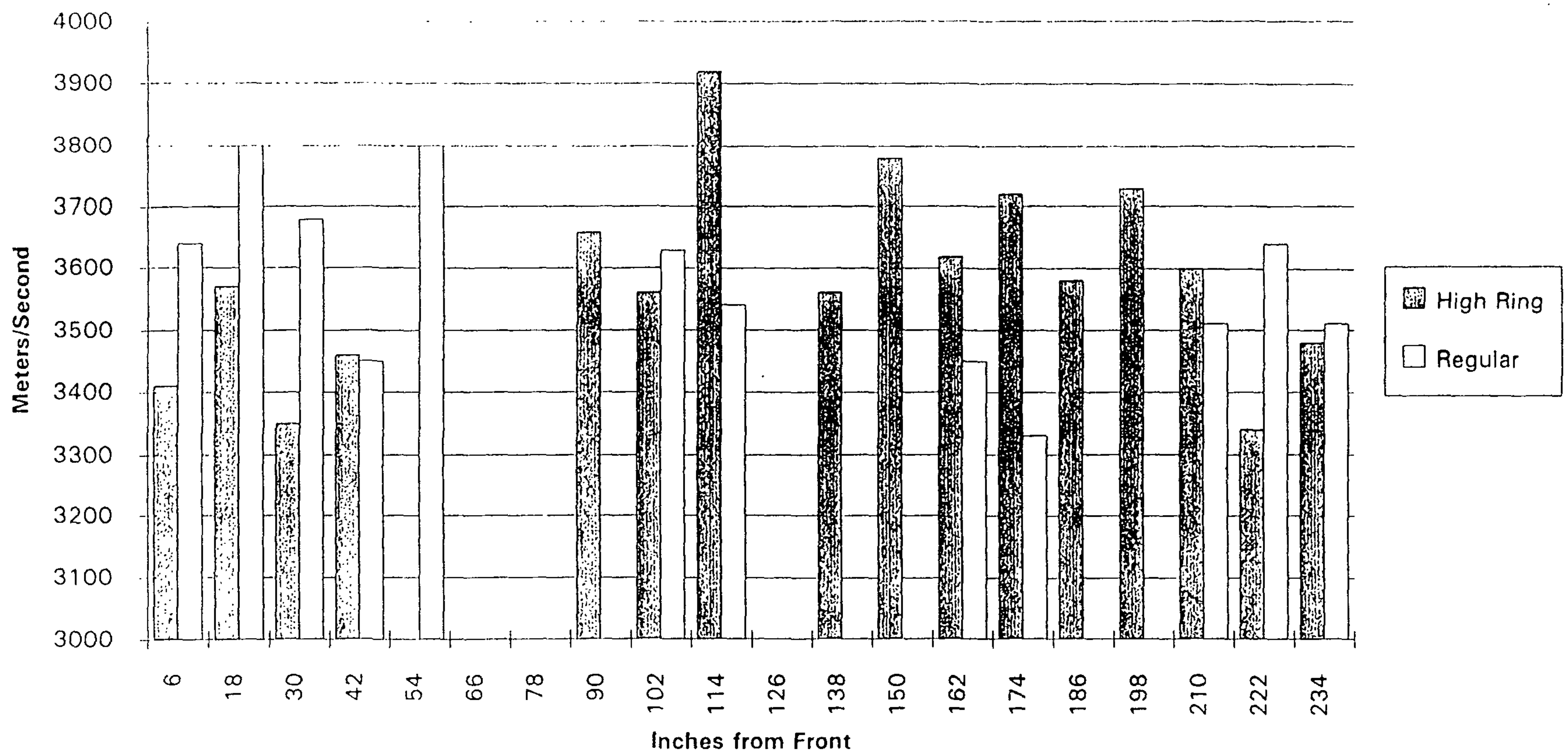
2_22_1.94 -> MD Longitudinal

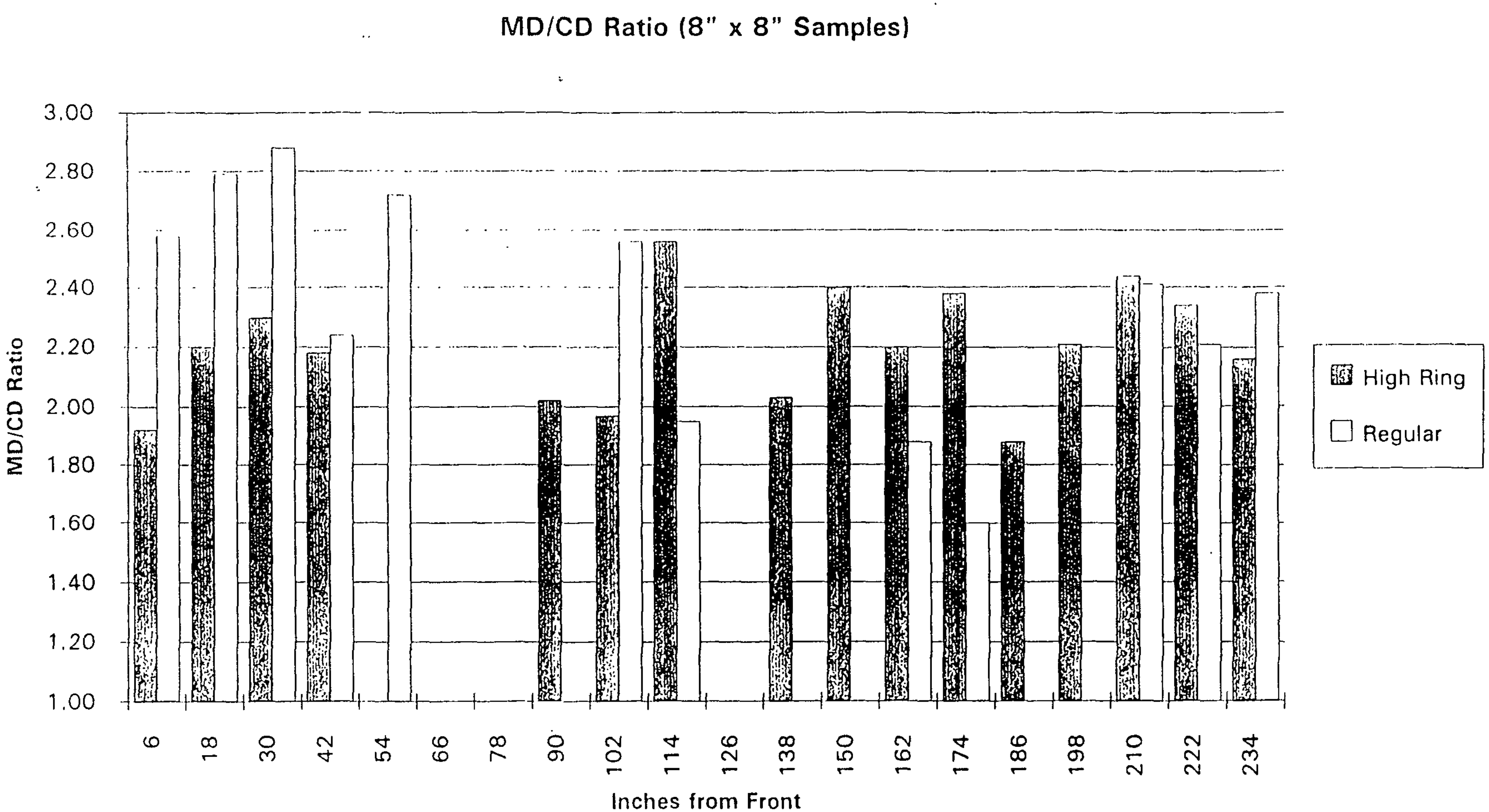


2_22_1.94 -> CD Shear

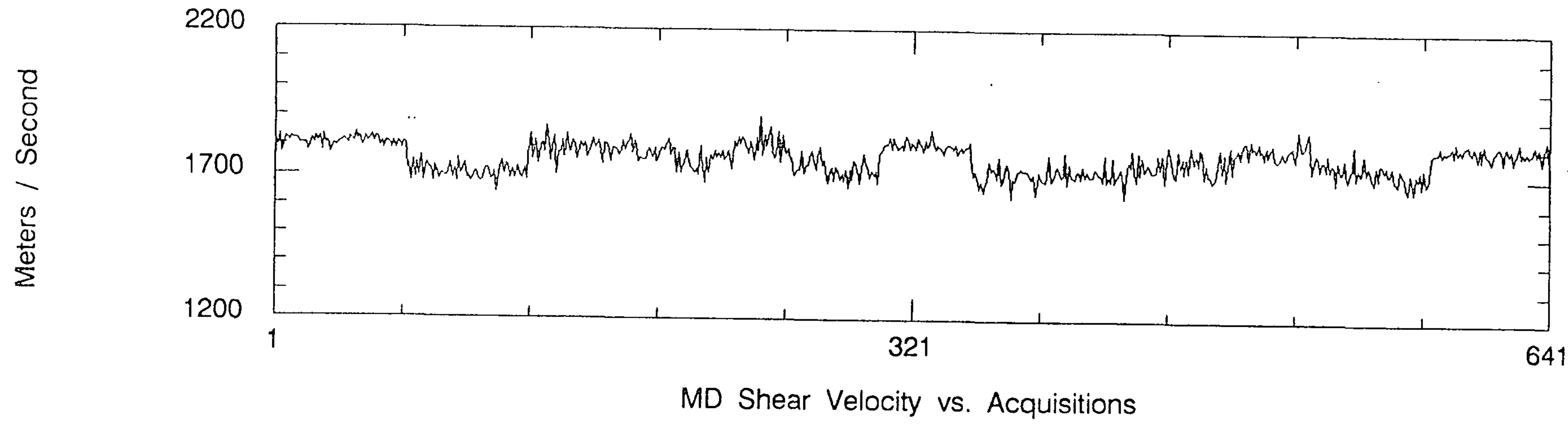


MD Longitudinal Velocity (8" x 8" Sample)

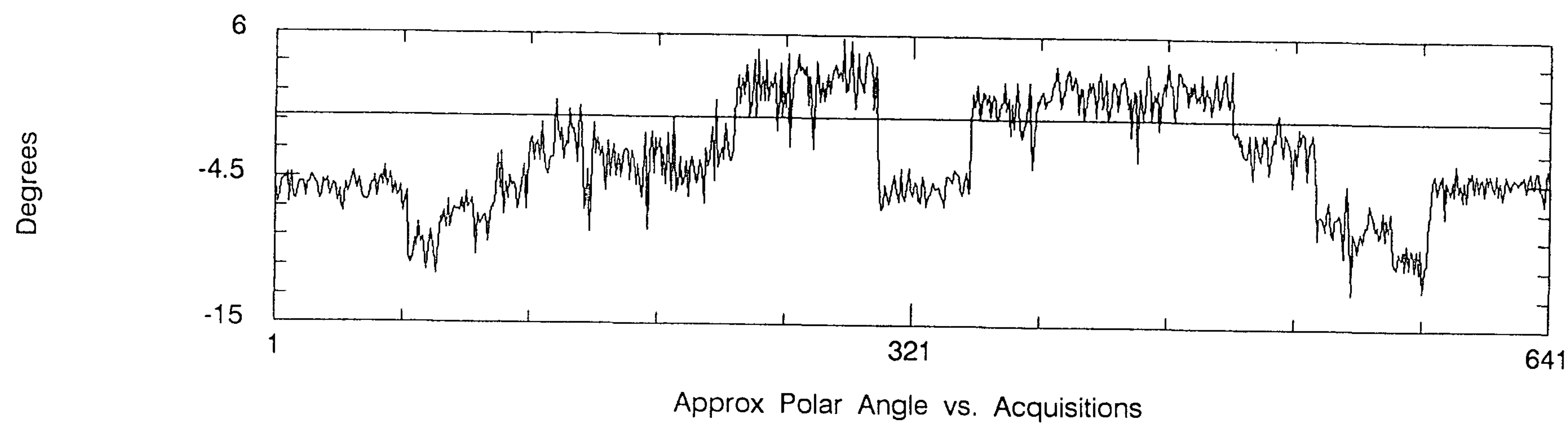



MD/CD Ratio (8" x 8" Samples)
MD/CD Ratio
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
6
18
30
42
54
66
78
90
102
114
126
138
150
162
174
186
198
210
222
234
Inches from Front
High Ring
Regular

2_23_2.94 -> 43-lb liner, High Ring & Reg



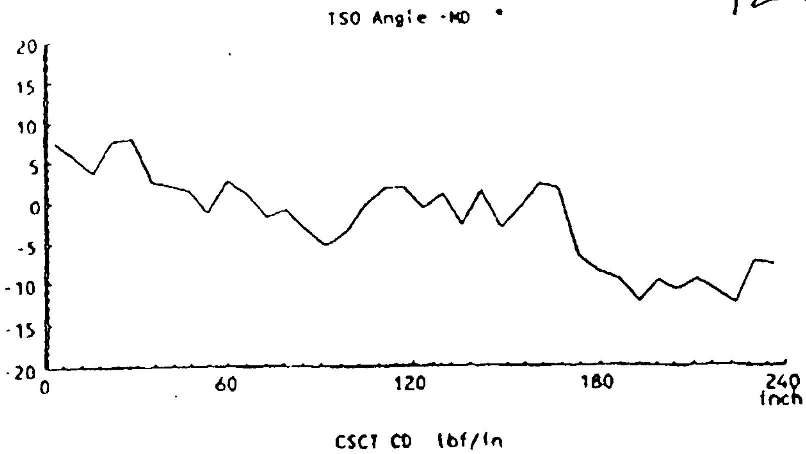
2_23_2.94 -> 42-lb liner, High Ring & Reg



L&W isotuner

No	PM02	Reel No 43	
de	LINER 42lb	Date =	09-27-1993
is Weight	205.0	Time	05:21

42 # High Ring Crush

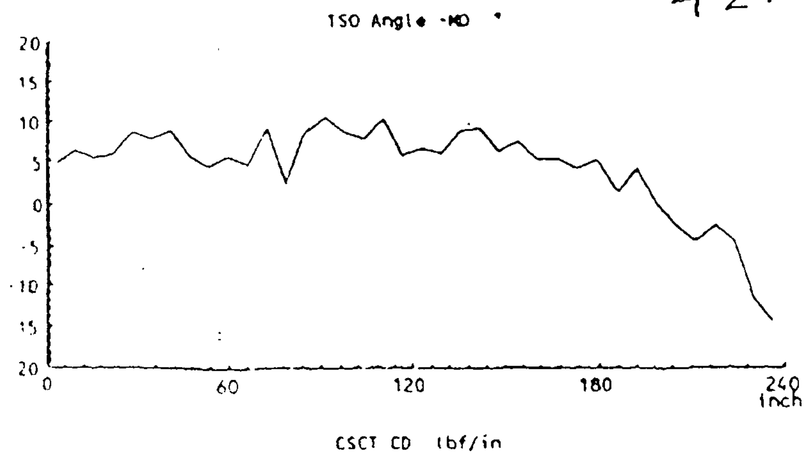


Meanvalue	-2.31
StdDev.	5.85
Min	-12.73
Max	7.89
No of values	38

L&W isotuner

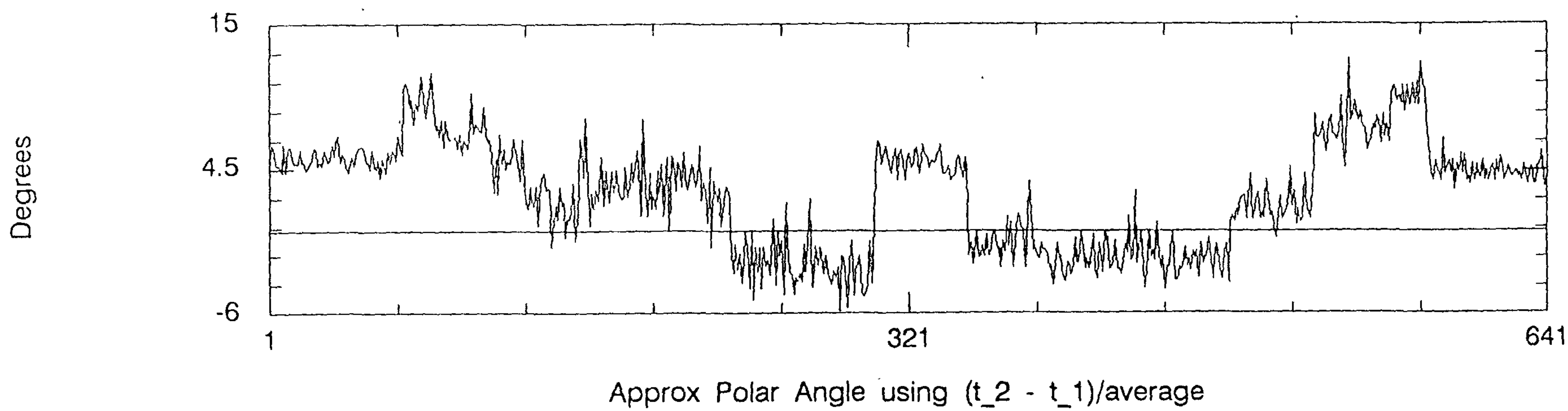
No	PM02	Reel No	
de	LINER 42lb	Date	09-28-1993
is Weight	205.0	Time	08:02

42 # Regular

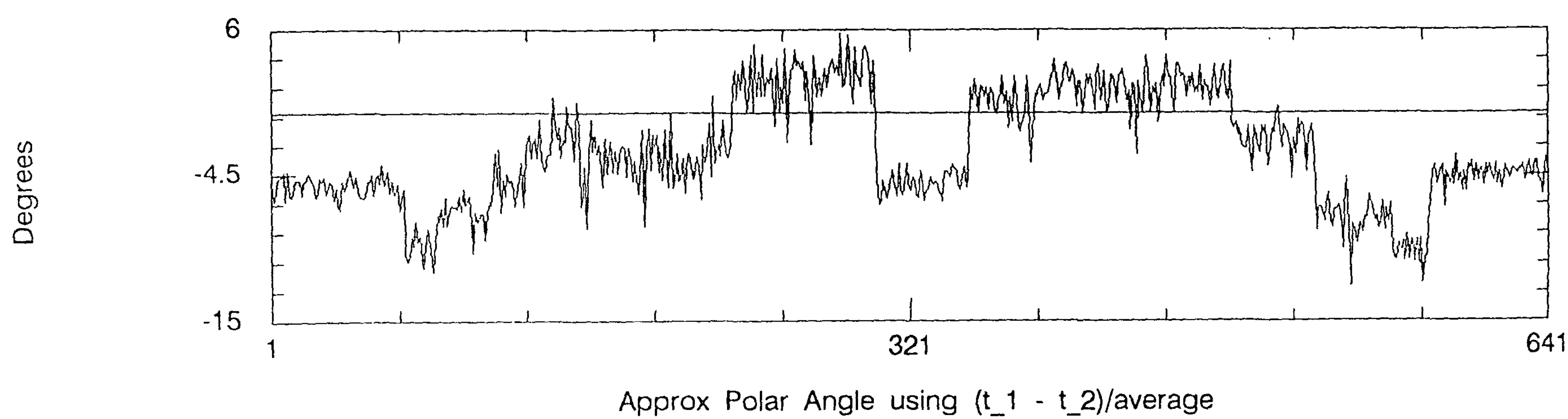


Meanvalue	4.18
StdDev.	5.54
Min	-14.45
Max	10.23
No of values	38

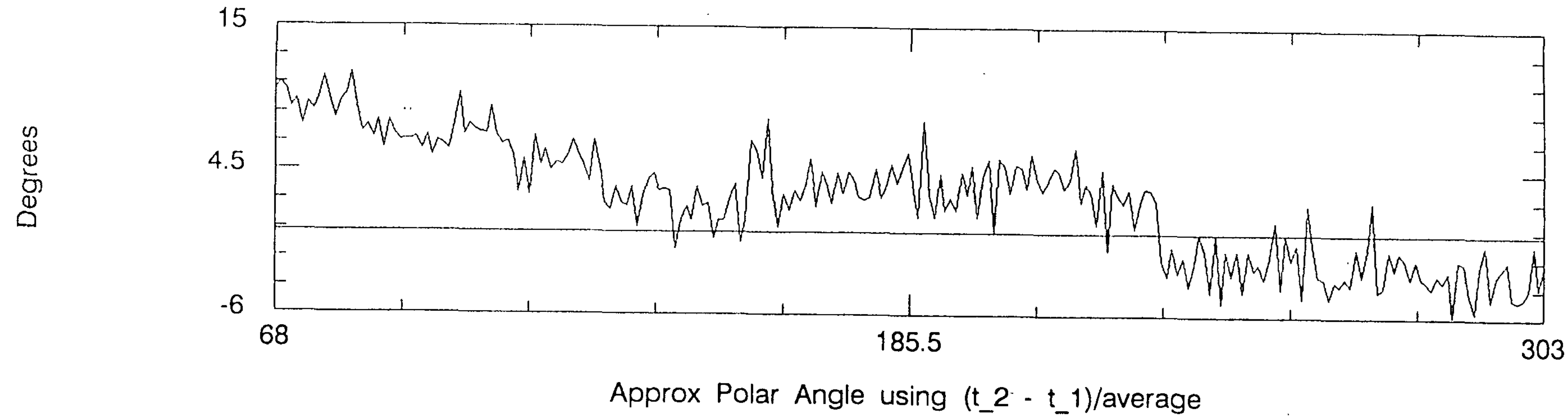
2_23_2.94 -> 42-lb liner, High Ring & Reg



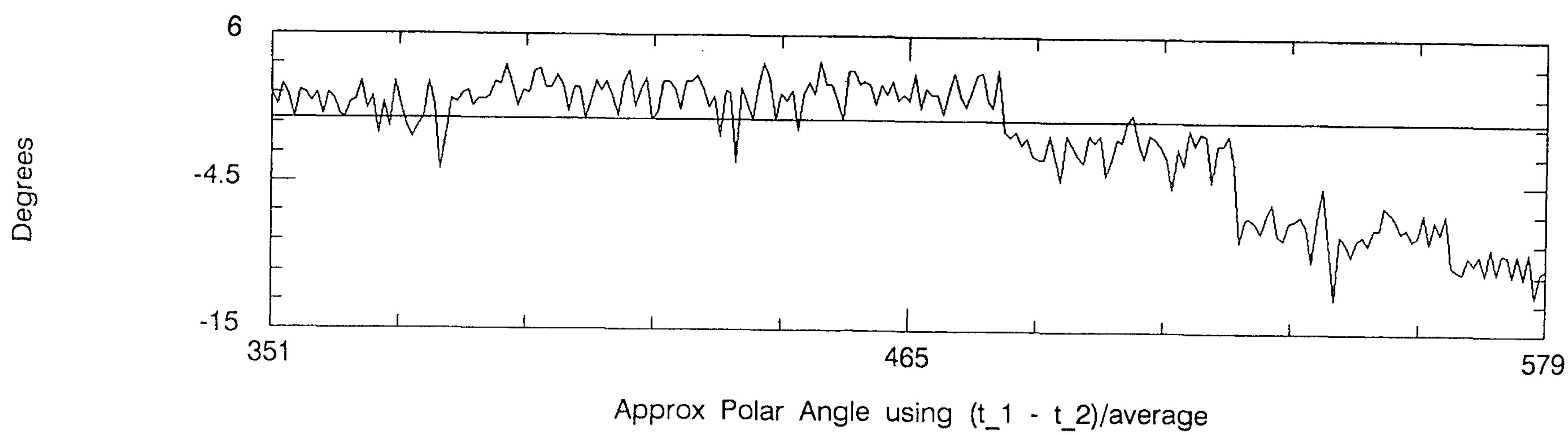
2_23_2.94 -> 42-lb liner, High Ring & Reg



2_23_2.94 -> 42-lb liner, High Ring



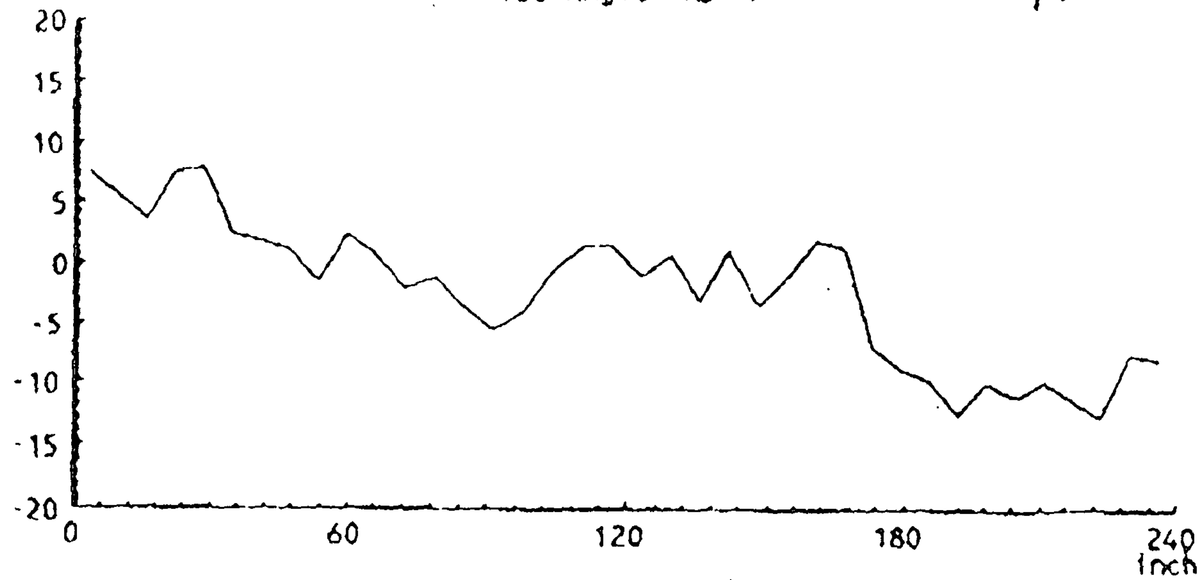
2_23_2.94 -> 42-lb liner, Regular



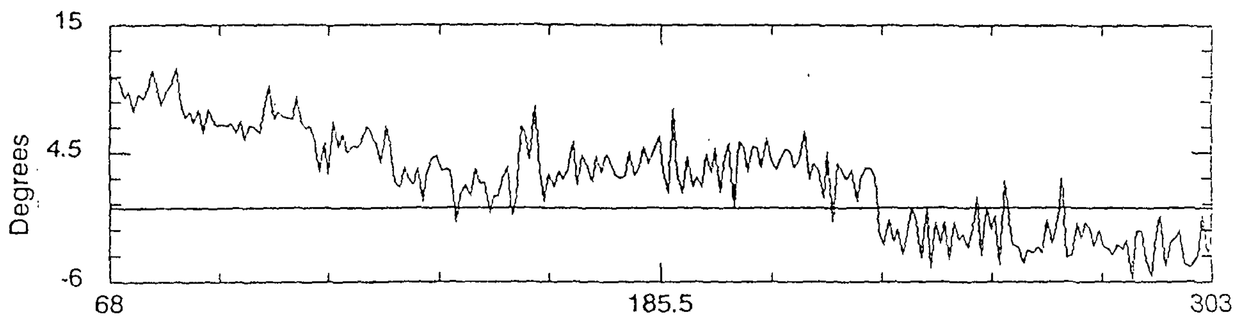
L&W isotuner

PM- No	PM02	Reel No
Grade	LINER 42lb	Date
Basis Weight	205.0	Time

42# Hi



2_23_2.94 -> 42-lb liner, High Ring

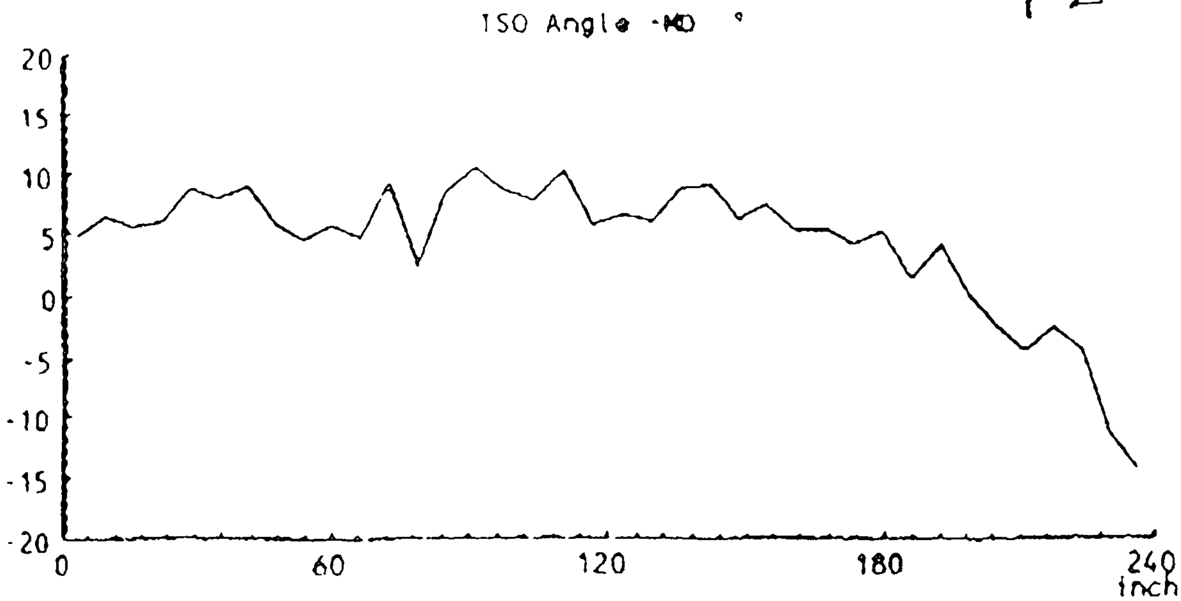


Approx Polar Angle using (t_2 - t_1)/average

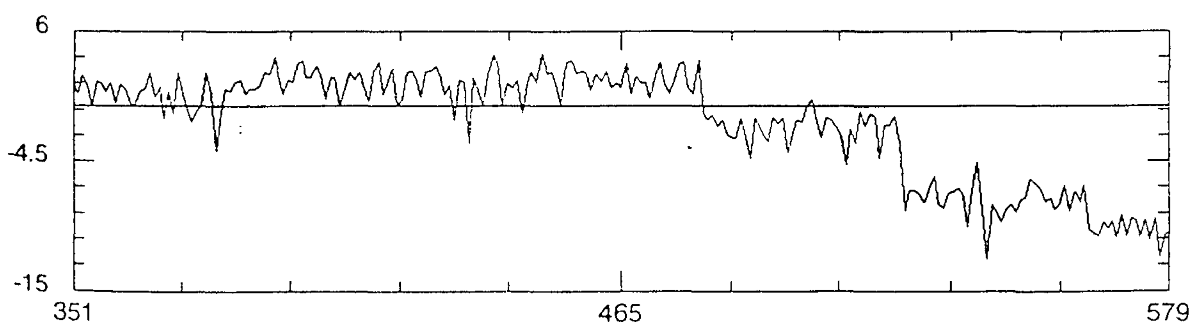
L&W isotuner

PM-No	PM02	Reel No	
Grade	LINER 42lb	Date	09
Basis Weight	205.0	Time	08

42# Reg



2_23_2.94 -> 42-lb liner, Regular



Approx Polar Angle using (t_1 - t_2)/average

CREEP RESPONSE OF SINGLE FIBERS

SLIDE MATERIAL

FOR

PROJECT A490

March 23, 1994
Institute of Paper Science and Technology
Atlanta, Georgia

Creep Response of Single Fibers

K. Sedlachek
Institute of Paper Science and Technology

Discussion Topics

I. Introduction

II. Theory of Fiber Creep

III. Thesis Hypothesis

IV. Experimental Approach

  A. Fiber Preparation

  B. Tensile Creep Measurements

V. Apparatus Overview

VI. Results

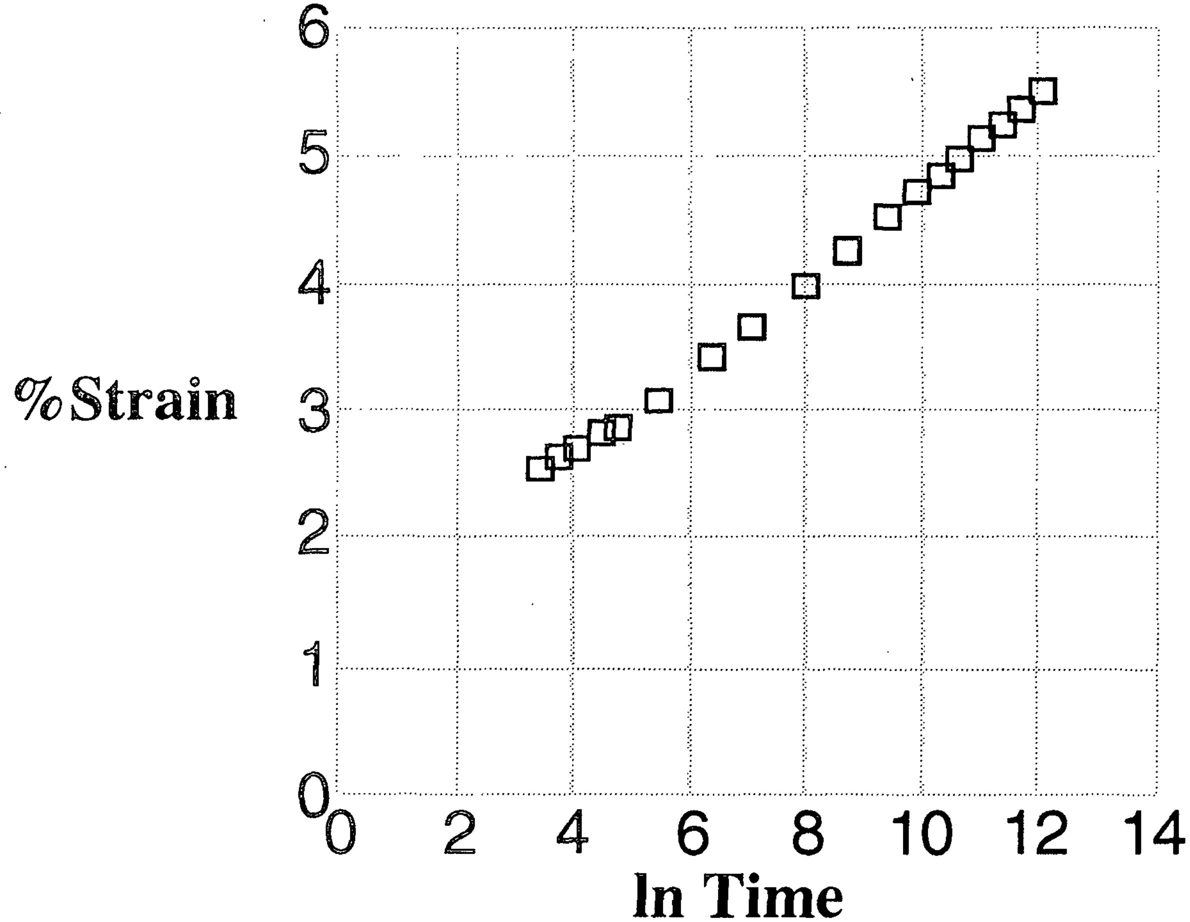
VII. Summary

Important Areas?	Why?
Corrugated Containers	**Lifetime**
Printing/Writing Papers	**Dimensional Stability**
Laminates	**Dimensional Stability** **Curl**

Single Fiber Creep Fitting (Hill)

Variable	Estimate	Standard Errors
α	3.738417E-09	3.0459757E-10
χ	1.804025E-09	2.6820907E-09
e_o	2.325207E-02	1.0600571E-03
e_i	6.851855E-02	5.4651355E-03

Computed Single Fiber Creep (Hill)



Fiber Type	E_1 (dynes/cm^2)
Acetate	5.6×10^{10}
Viscose Stable Fiber	8.4×10^{10}
Viscose Continuous Filament	13.9×10^{10}
Longleaf Pine (Hill data)	16.0×10^{10}

Theoretical Fiber Modulus

Comparison of fiber modulus to theoretical calculations of Meyer and Lotmar.

Longleaf Pine (Hill data)	(dynes/cm^2)
E_1	16×10^{10}
E_2	$+ \ 8 \times 10^{10}$
E	24×10^{10}
$E_{theoretical}$	89×10^{10}

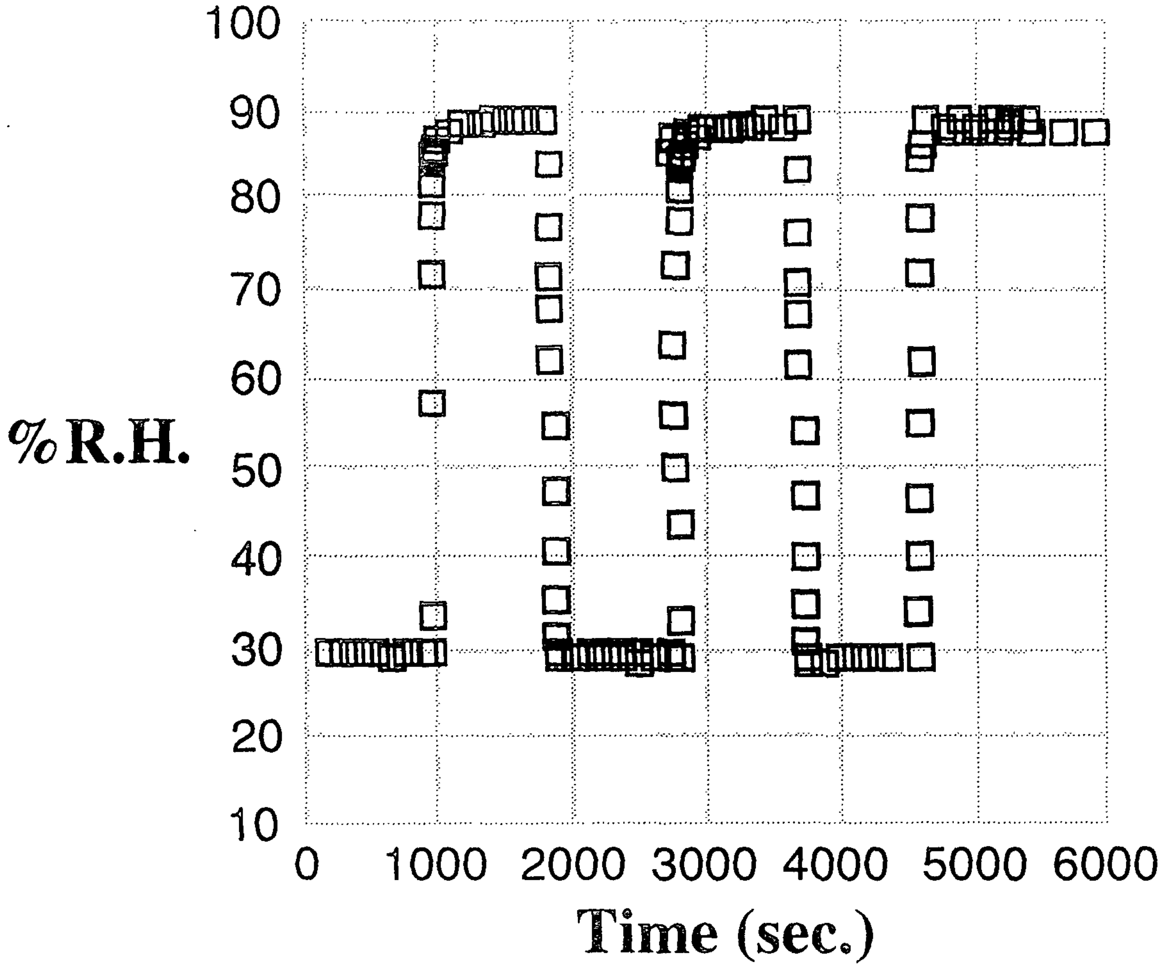
Thesis Hypothesis

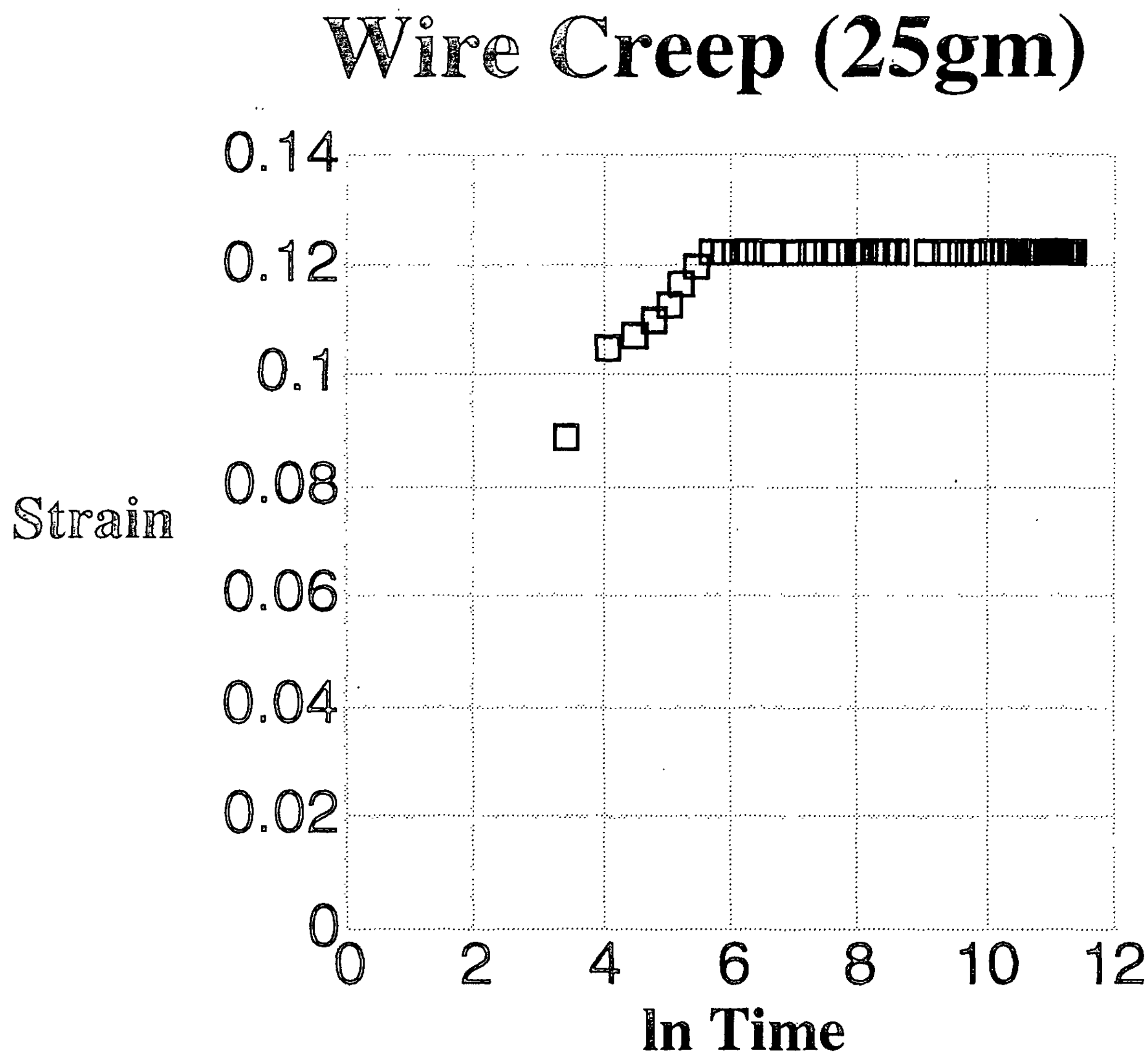
Hemicelluloses influence tensile creep behavior of individual pulp fibers as a function of constant and cyclic humidity conditions.

Experimental Approach

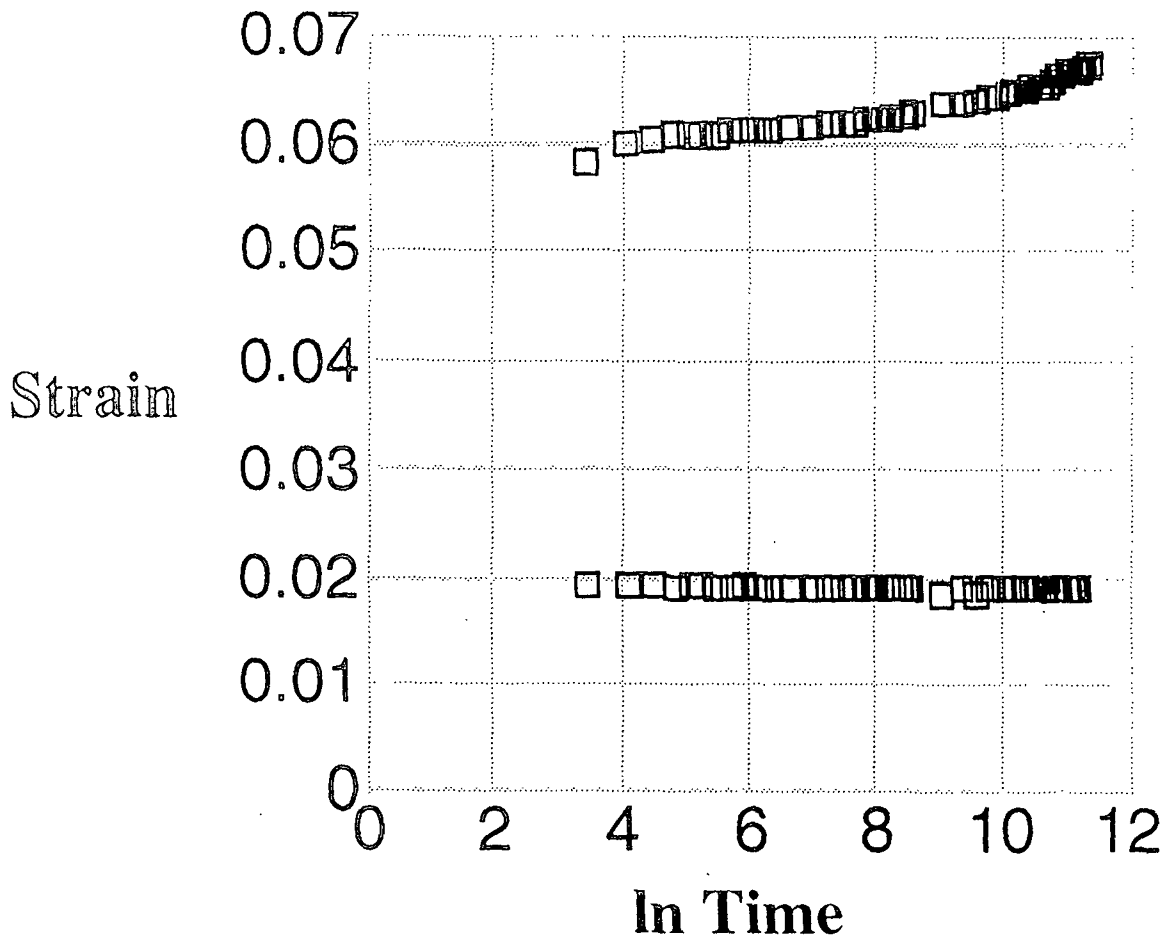
Fiber Sample	%RH
Loblolly Pine Holocellulose	30
	50
	90
	30-90(cycled)
Extracted Loblolloy Pine Holocellulose	30
	50
	90
	30-90(cycled)

Relative Humidity Control

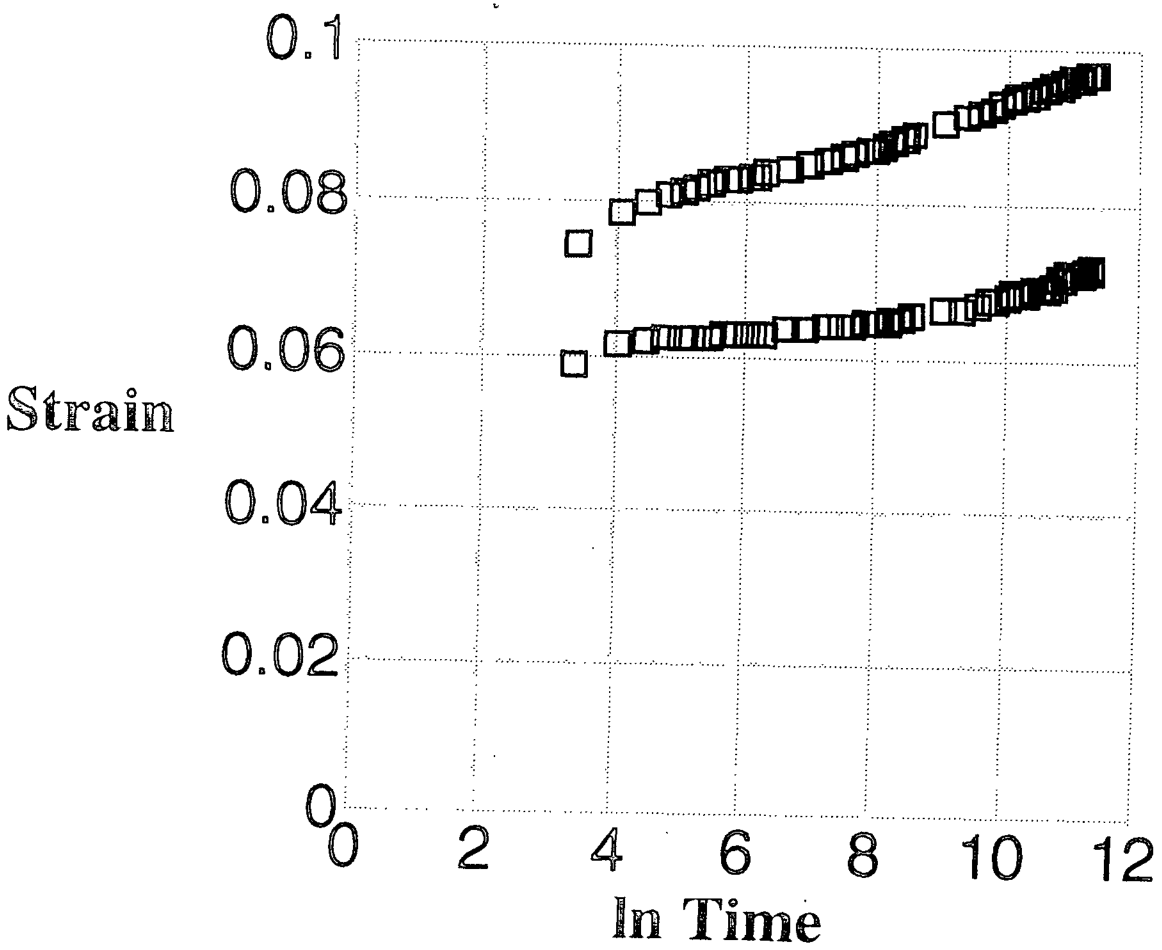



Wire Creep (25gm)
Strain
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
ln Time

Holocellulose Single Fiber Creep (20gm)



Single Fiber Creep (20gm)



Summary

- Erying's theory of tensile creep has been shown to fit single fiber creep data at 50%RH. The free energy is about 29,000 cal/mole.
- Pulp samples have been prepared at varying levels of hemicellulose content.
- The FLERII device has been modified to continuously moitor creep.
- Initial data shows a significant difference in extracted holocellulose and holocellulose creep.

Acknowledgement

Institute of Paper Science and Technology and its Member Companies

Dr. R. L. Ellis
Dr. B. Livesay
Dr. T. McDonough

FUNDAMENTALS OF ACOUSTIC RADIATION PRESSURE

SLIDE MATERIAL

FOR

PROJECT 3767

March 22, 1994
Institute of Paper Science and Technology
Atlanta, Georgia

FUNDAMENTALS OF ACOUSTIC RADIATION PRESSURE

PROJECT 3767

PIERRE BRODEUR

Engineering and Paper Materials Division
Institute of Paper Science and Technology

March 23, 1994

OUTLINE

- OBJECTIVES
- BACKGROUND
- PROJECT STATUS
- CONCLUSION
- **FUTURE WORK**

OBJECTIVES

- TO UNDERSTAND EFFECTS OF ACOUSTIC RADIATION PRESSURE ON FLUID SUSPENDED FIBERS
- TO UNDERSTAND MECHANISMS OF ACOUSTIC FIBER AGGLOMERATION AND FIBER REORIENTATION UNDER ZERO-FLOW AND FLOW CONDITIONS

OBJECTIVES

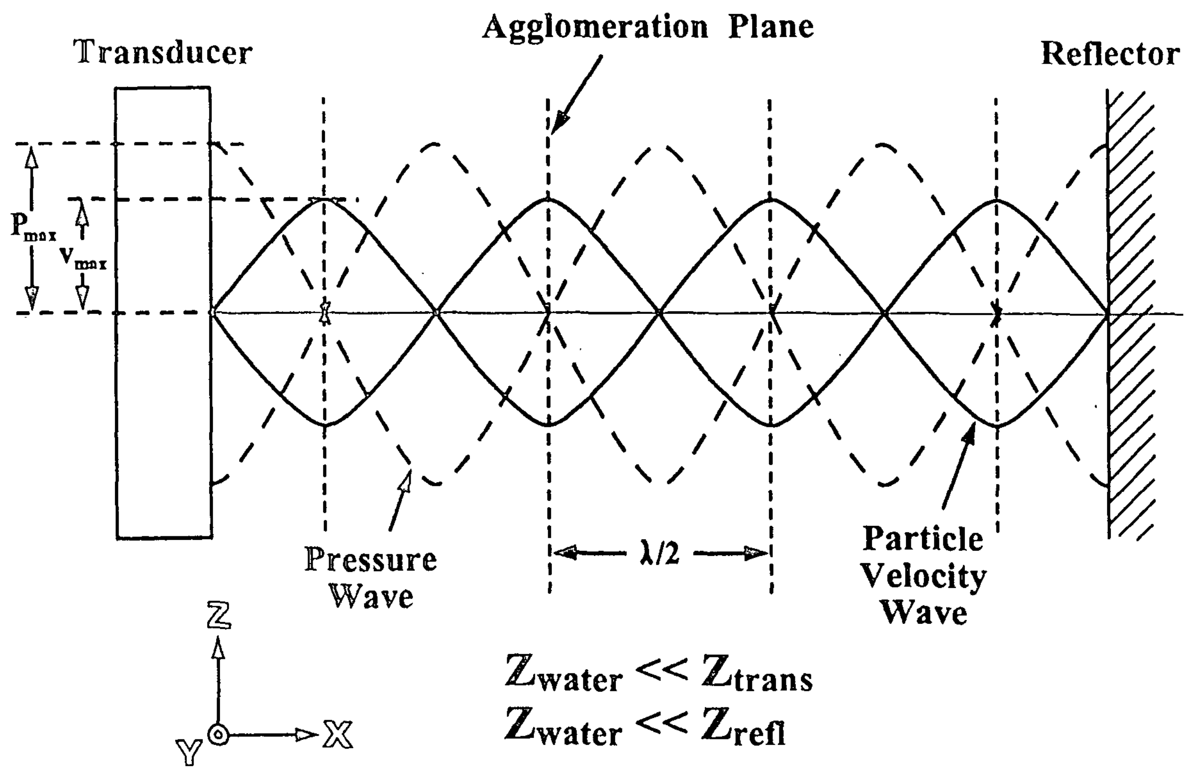
- TO DEMONSTRATE THE CONCEPT OF ACOUSTIC WET FIBER FLEXIBILITY

- TO INVESTIGATE PROCESS-RELATED APPLICATIONS OF ACOUSTIC RADIATION PRESSURE

BACKGROUND

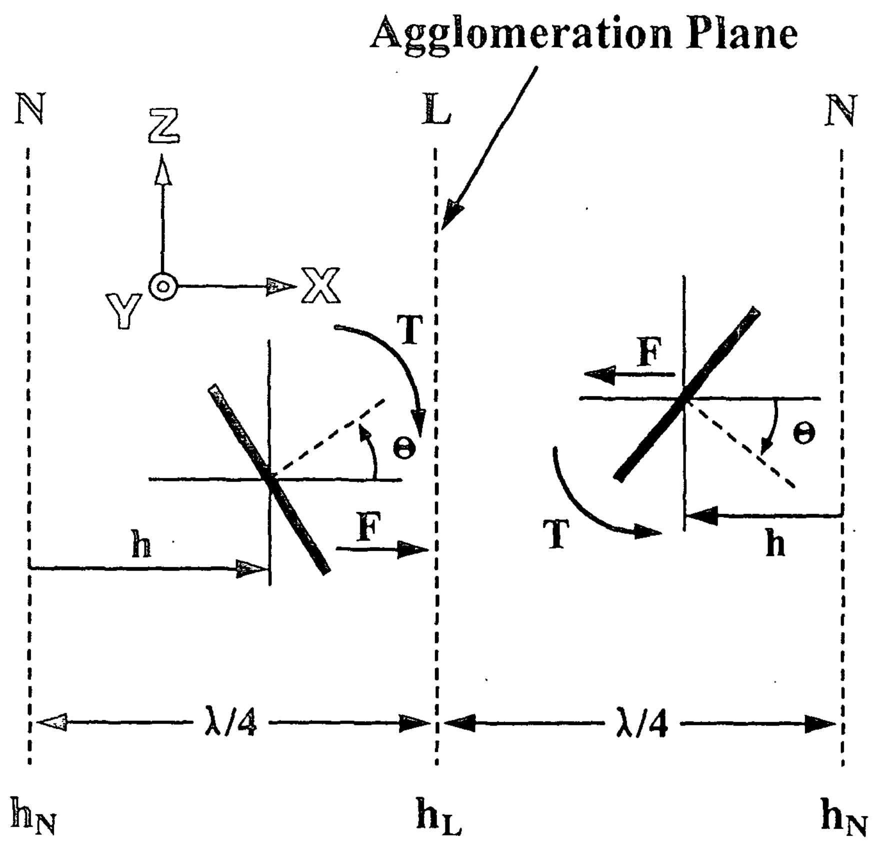
- TRAVELING WAVE FIELD VS. STANDING WAVE FIELD
- ACOUSTIC RADIATION PRESSURE EFFECTS (CASE OF STANDING WAVE FIELD)
- ACOUSTIC RADIATION FORCE
- ACOUSTIC RADIATION TORQUE

STANDING WAVE FIELD



$Z_{water} << Z_{trans}$
$Z_{water} << Z_{refl}$

ACOUSTIC RADIATION FORCE AND TORQUE



ACOUSTIC RADIATION FORCE
(STANDING WAVE FIELD)

$$F_{SW} = f(\beta)\frac{\pi a^2}{2}\bar{E}\sin[2kh]$$

$$f(\beta) = [2(1-\beta)/(1+\beta)+1]$$

$$\beta = \rho_0 / \rho_1$$

ACOUSTIC RADIATION TORQUE
(STANDING WAVE FIELD)

$$T_{SW} \propto -(\pi a^2 \ell)\overline{E}\sin[2\theta]\sin^2[kh]$$

PROJECT STATUS

- EXPERIMENTAL PROGRAM
  - EXPERIMENTAL SETUP
  - PRELIMINARY OBSERVATIONS
  - ACOUSTIC FRACTIONATION
  - ACOUSTIC WET FIBER FLEXIBILITY

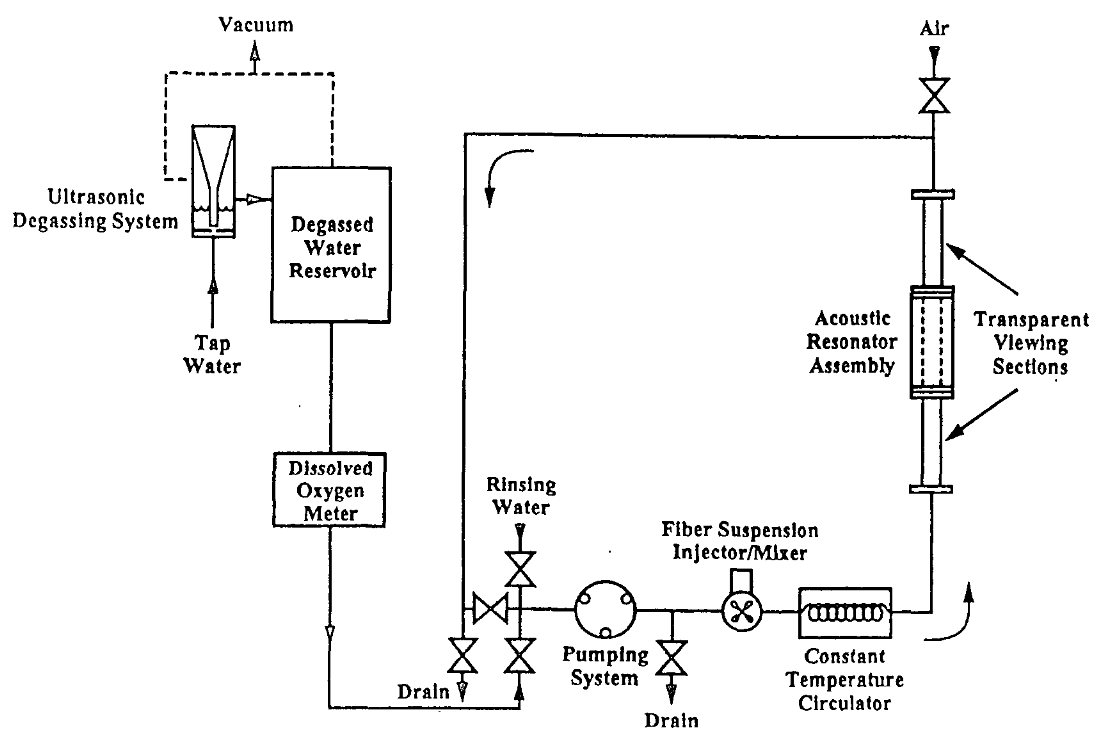
- THEORETICAL/NUMERICAL PROGRAM
  - ACOUSTIC WET FIBER FLEXIBILITY

EXPERIMENTAL PROGRAM

- EXPERIMENTAL SETUP
  - FLOW LOOP SYSTEM
  - ULTRASONIC DEGASSING SYSTEM
  - TRANSDUCER DRIVING SYSTEM
  - OPTICAL MONITORING SYSTEM

- SYSTEM CAPABILITIES:
  - CONSISTENCY UP TO 1%
  - ZERO-FLOW AND LAMINAR FLOW CONDITIONS

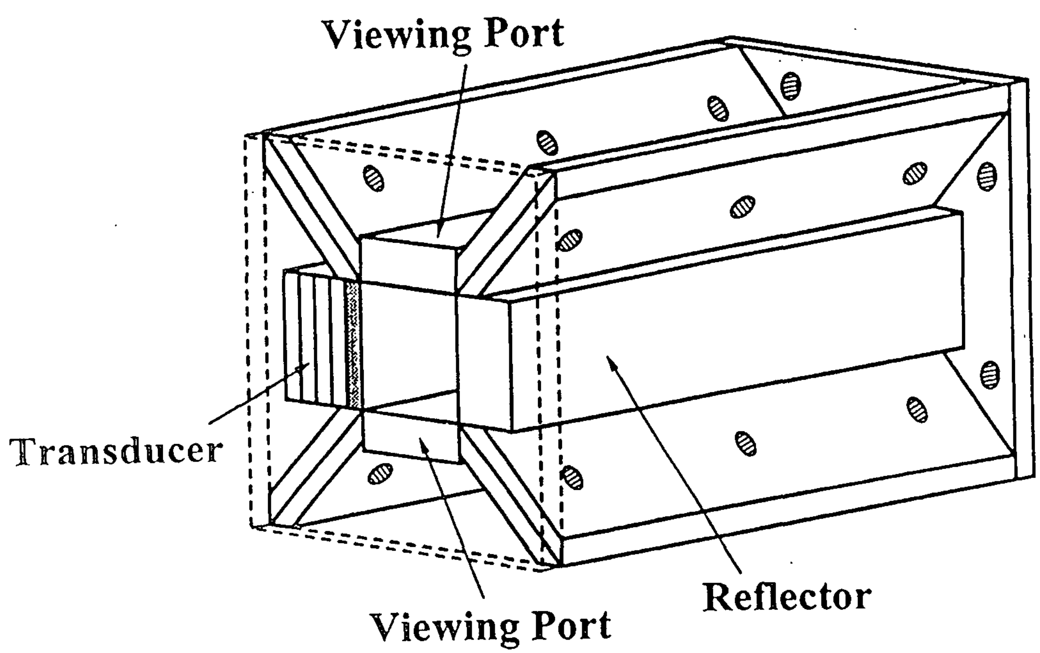
EXPERIMENTAL SETUP



RESONATOR ASSEMBLY

- TRANSDUCER RESONANT FREQUENCY: 150 kHz
- ACOUSTIC WAVELENGTH (in water): 1 cm
- CAVITY DIMENSIONS: 2 X 2 X10 cm^3
- NUMBER OF AGGLOMERATION PLANES: 4

RESONATOR ASSEMBLY



PRELIMINARY OBSERVATIONS

- RAYON FIBERS
  - STANDING WAVE FIELD (DEGASSING)
  - CONSTANT LENGTH (3.2 mm)
  - VARIABLE DIAMETER (5.9 μm and 10.2 μm)
  - VARIABLE CONSISTENCY (0.01%, 0.1%, and 1%)
  - FLOW VELOCITY (0, 2.5 cm/s and 12.5 cm/s)
  - REYNOLDS NUMBER (0, 500, and 2500)

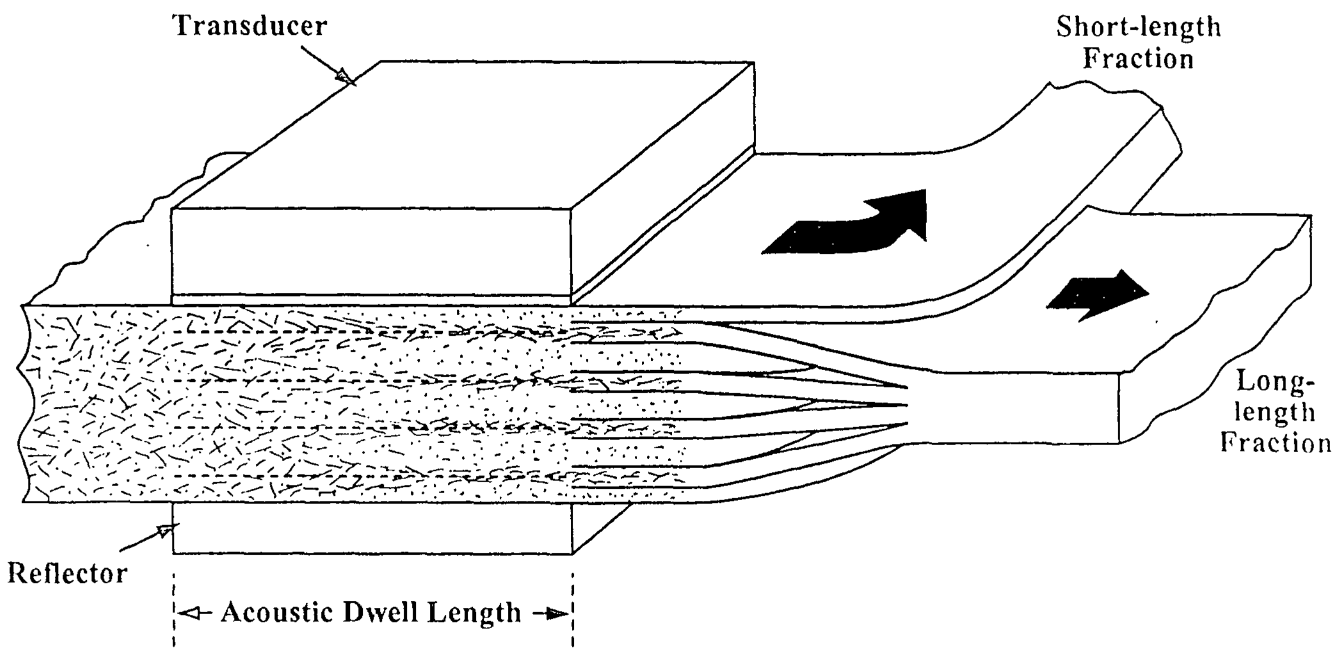
PRELIMINARY OBSERVATIONS

- OCC FIBERS
  - TRAVELING WAVE FIELD (NO DEGASSING)
  - FLOW VELOCITY (10 cm/s)
  - REYNOLDS NUMBER (2000)
  - OBSERVATIONS USING WHOLE PULP AND FINES FRACTION

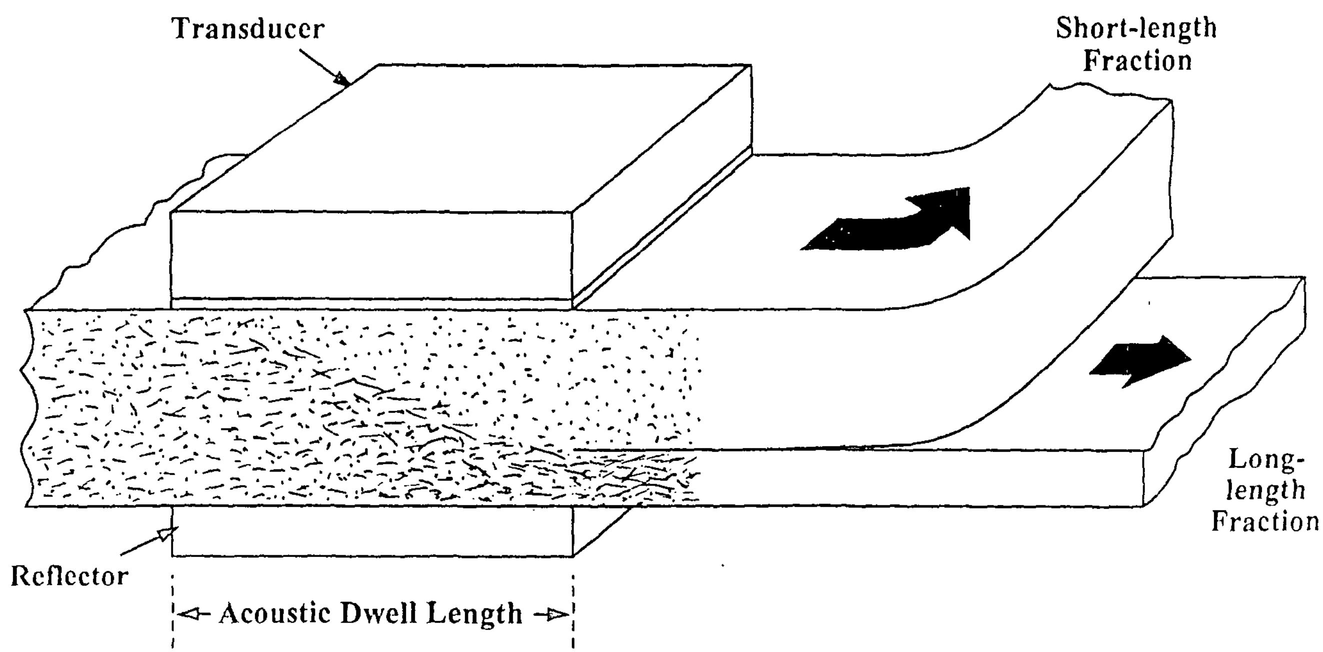
ACOUSTIC FRACTIONATION

- PROPOSED FRACTIONATION SCHEMES:
  - STANDING WAVE FIELD CONCEPT
  - TRAVELING WAVE FIELD CONCEPT
  - ACOUSTIC FRACTIONATOR/CLARIFIER CONCEPT

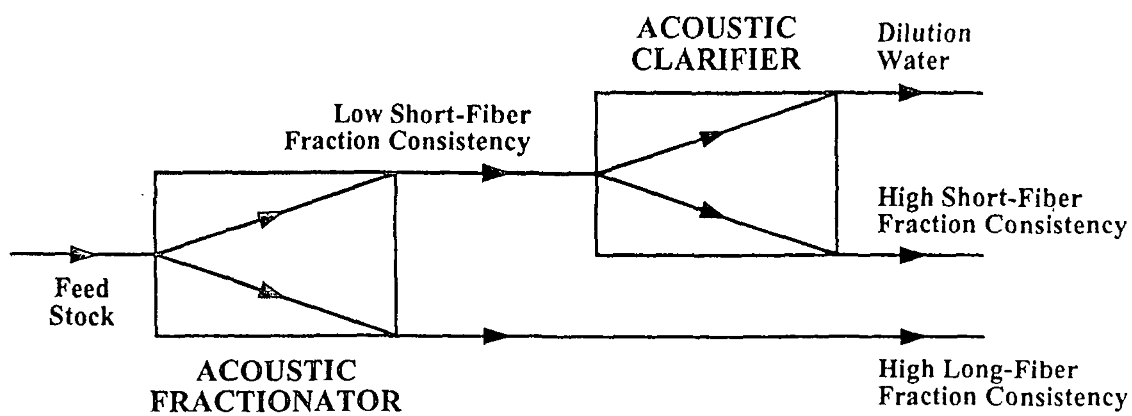
STANDING WAVE FIELD CONCEPT



TRAVELING WAVE FIELD CONCEPT



ACOUSTIC FRACTIONATOR/CLARIFIER CONCEPT



ACOUSTIC WET FIBER FLEXIBILITY

- USE OF AN ACOUSTIC FIELD TO INDUCE DEFLECTION OF WET FIBERS

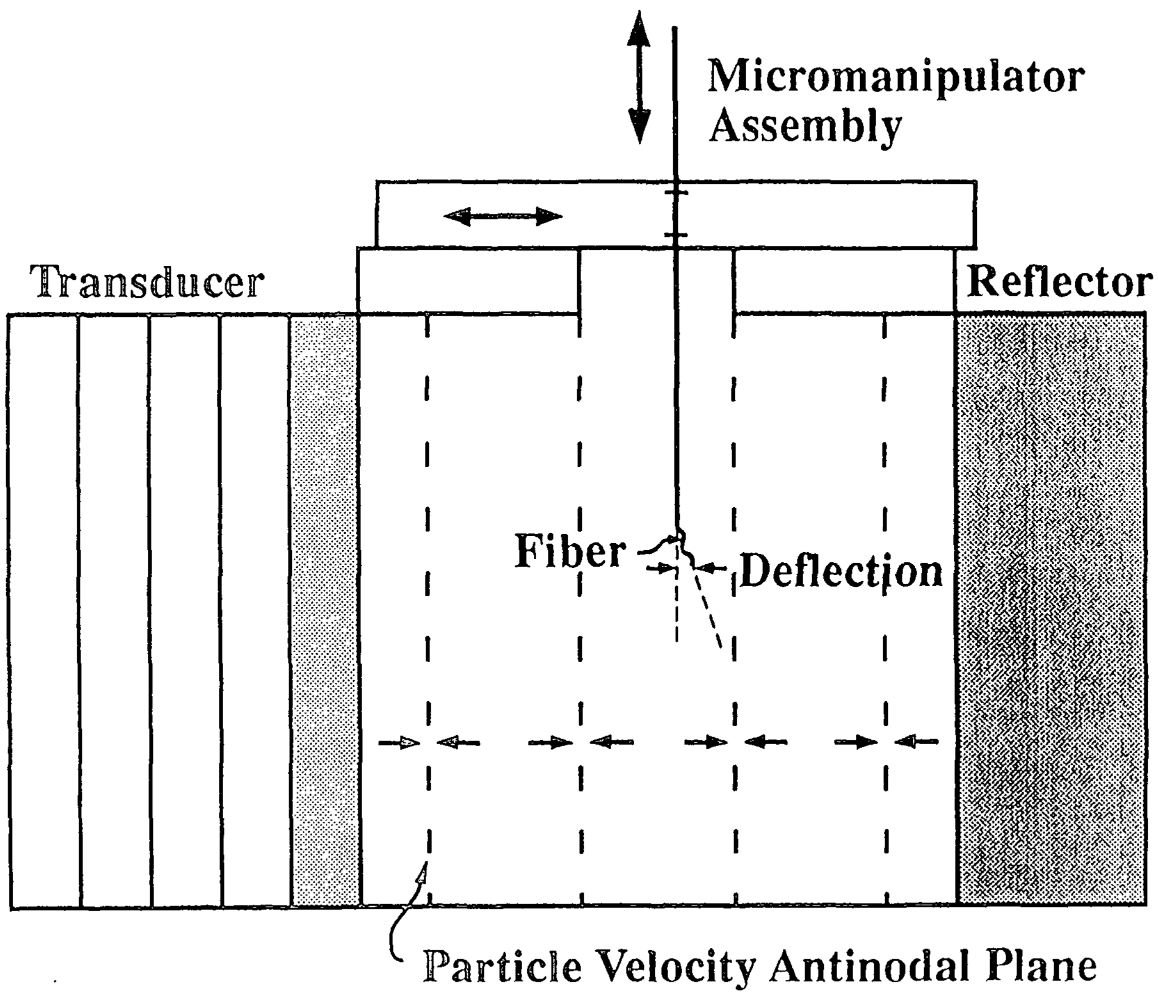
- INITIAL STEP: SINGLE FIBER MOUNTED AS A CANTILEVER BEAM

- USE OF AN IMAGING SYSTEM TO RELATE FIBER DEFORMATION TO ACOUSTIC PARAMETERS

ACOUSTIC WET FIBER FLEXIBILITY

- SUBSEQUENT STEPS:
  - ACOUSTIC DEFLECTION OF FIBERS EXITING A CAPILLARY TUBE
  - FIBER SUSPENSION INTERACTING WITH A 3-D "ACOUSTIC GRID"

ACOUSTIC WET FIBER FLEXIBILITY



THEORETICAL/NUMERICAL PROGRAM

- INITIAL FOCUS OF ACOUSTIC WET FIBER FLEXIBILITY

- USE OF AN ENERGY METHOD (ASSUMED-MODE METHOD) TO STUDY THE DEFLECTION OF A CANTILEVER BEAM SUBJECTED TO AN EXTERNAL FORCE (ACOUSTIC FORCE)

MATRIX FORM OF THE LAGRANGE'S EQUATIONS OF MOTION

$$[m]\{\ddot{q}(t)\}+[k]\{q(t)\}=\{Q(t)\}$$

- WHERE:
  - [m] : MASS MATRIX
  - [k] : STIFFNESS MATRIX
  - q(t) : GENERALIZED COORDINATES
  - Q(t) : GENERALIZED NONCONSERVATIVE FORCES

CONCLUSION

- DEMONSTRATION OF ACOUSTIC FIBER AGGLOMERATION AT CONSISTENCIES UP TO 1% AND AT REYNOLDS NUMBERS UP TO 2500

FUTURE WORK

- COMPLETE EXPERIMENTAL SETUP TO PERFORM QUANTITATIVE MEASUREMENTS OF ACOUSTIC FIBER AGGLOMERATION AND REORIENTATION
- BEGIN ACOUSTIC WET FIBER FLEXIBILITY EXPERIMENTS
- DEVELOP A MODEL TO PREDICT FIBER BENDING